Volume 83 Number 9

# INDUSTRIAL ENGINEER

*Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories*

McGraw-Hill Company, Inc.
JAMES H. MCGRAW, *President*
JAMES H. MCGRAW, JR., *Vice-Pres.-Treas.*

Chicago, September, 1925

G. A. VAN BRUNT, *Managing Editor*

# Housekeeping in a Factory

## *With Some Sidelights on How They Do It in the Shops of the Buick Motor Company*

A SHORT while ago I was looking through a copy of the *Buick News*, a house organ which is marked, "Published in the interests of the entire Buick family." And so it is, for in that particular issue a double page of pictures showed what Buick foremen are doing to aid production through an organized program of keeping things in order about the shops they are responsible for. Good housekeeping in a large factory is just as much a family affair as in the home, and with a little co-operation all along the line the job is an easy one for all, and brings results that are pleasantly surprising. Just take a look at the accompanying pictures—they tell a real story.

I secured these pictures by writing to R. F. Thalner, safety director for the Buick Motor Company, at Flint, Mich., and with them came the following letter:

"The names of the foremen in the two departments which you asked about are Nottingham and Miller. These men are in charge of the departments as shown in the layout of the *Buick News*. The additional photographs which I am sending are from Mr. Maxell's department, who was the first foreman to initiate this campaign. If any mention is given, we desire to have his name used, inasmuch as he really started the ball rolling and created the competition among the other foremen. The general plan of procedure in this housecleaning campaign was to become familiar with the general conditions, and have pictures taken of the department in which the cluttered-up conditions showed up the worst.

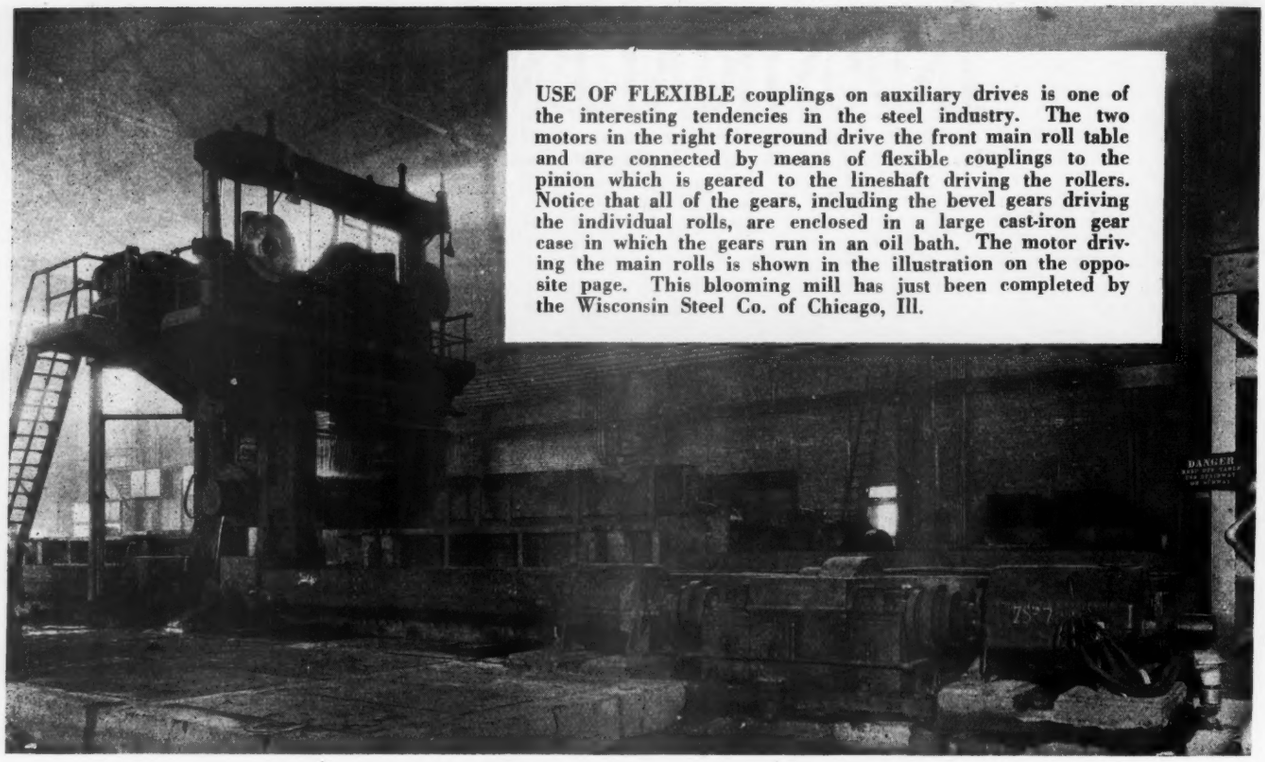
"It was easy to sell the foreman on keeping the department clean for these reasons: It would give him a certain amount of floor space that he had never been able to use; it would allow him to pile his stock in an orderly condition; and it would make it a great deal easier for men and materials to move around the department. After the department was put in order, another picture was taken showing the improvement made. Both pictures were then posted in the department so the men might see the difference.

"As the experiment that started in Mr. Maxell's department has grown to such astonishing proportions, Mr. C. E. Hendricks, superintendent of plants 31, 32, 33 and 38 suggested that we start using a score card, with a passing score of 70 and a perfect score of 100. The carrying out of this suggestion has created more enthusiasm and friendly rivalry among the foremen and has been a stimulus for keeping the movement under way. In addition to the score card, a report was sent to L. D. Parker, manager of these factories, advising him of the standing of the various departments. He was then able to consult with his superintendents regarding the low standings of any particular factory or department and ask them to raise the rating of that department. The inspections were made by my assistant, Mr. E. E. Widmark, who co-operated with Mr. Maxell in starting the movement."

Mr. Thalner has told the whole story with an enthusiasm for the idea that must be catching in Buick factories. Foremen Maxell and Miller have worked out the idea close to 100 per cent, as shown in the accompanying pictures taken before and after the cleaning up, but that is not all. Foremen Brazill, Fisher, McRoe, Casey, Scranton and Heller and, by this time, probably several more are among those on the honor roll in factories 31 to 38 for keeping their departments in a condition that looks good through the camera lens.

This is a worth-while program. What are you doing along a similar line?

Practical Pete



USE OF FLEXIBLE couplings on auxiliary drives is one of the interesting tendencies in the steel industry. The two motors in the right foreground drive the front main roll table and are connected by means of flexible couplings to the pinion which is geared to the lineshaft driving the rollers. Notice that all of the gears, including the bevel gears driving the individual rolls, are enclosed in a large cast-iron gear case in which the gears run in an oil bath. The motor driving the main rolls is shown in the illustration on the opposite page. This blooming mill has just been completed by the Wisconsin Steel Co. of Chicago, Ill.

*New Trends and Recent Progress in Solving*

# Problems of Steel Mill Operation

## *That Involve the Use of Electrical and Mechanical Power-Drive Equipment, Together with Tendencies in Power Generation, Distribution, and Application*

By ARTHUR J. WHITCOMB

*Associate Editor, Industrial Engineer*

TO AN even greater extent than usual, this past year has been marked by a replacement of existing steam engine drives with modern electrical equipment. This has been brought about by severe competition due to lack of foreign markets and to an excess of steel-making capacity. To meet competition, operators have been striving in every possible way to reduce operating costs and replacement of engine drives with electrical equipment has been one way of lowering these costs. It is interesting to note that out of 95,225 hp. in motors reported by one electrical manufacturer as sold during the year, 13 units totaling 23,750 hp. or approximately 25 per cent of the total represents motors that were purchased to replace existing steam engine drives.

One of the most radical change-overs from steam to electric drive in the history of the steel industry is to be made by the Colorado Fuel & Iron Company at its Minnequa Works, Pueblo, Col. Complete electrical equipment will be furnished for replacing the engine drives on a rod mill, a 10-in. merchant mill, a 14-in. merchant mill and a rail mill. The sizes of these drives are listed in the accompanying table. Five of these drives are direct-current, adjustable-speed motors, which are supplied from rotary converters.

The induction motor still meets, in some of its several forms, most requirements for main roll drives, except for reversing duty, where the direct-current machines with generator and motor field control continue to hold sway. Most induction motors now used are of higher speeds and are geared to the main roll drives. Gear reduction units have reached a high degree of reliability and efficiency, and their use in this connection with induction motors is becoming almost universal, as may be seen from the table shown on page 408.

The growing demand for high-tonnage mills with great flexibility in range of product is, however, requiring more and more adjustable-speed, direct-current motors which in turn is giving more importance to the question of whether motor-generators, rotary converters or mercury arc rectifiers should be used for

transforming from alternating to direct current.

For certain types of mills synchronous motors for driving the main rolls have been considered very favorably by many of the operators interviewed. At one plant visited an unusually large installation was considered for a piercing mill, while at another plant synchronous motors were contemplated for use on cold rolls. Several installations have been made in some tube rolling and piercing mills. However, the motors used are 1,000 hp. or less in rating. Just recently a 9,000-h.p. synchronous motor has been purchased by the McKinney Steel Company for direct connection to a Morgan continuous billet mill at its River Furnace plant in Cleveland, Ohio. The motor will have a shaft extension on both ends and will be coupled to a long lay shaft running the length of the mill, with bevel gearing to each of the ten roll stands. This is said to be the first large steel rolling mill in the world to be driven by a synchronous motor. In fact, the motor with its rating of 9,000 hp., 107 r.p.m, 6,600 volts, three phase, 25 cycles, is reported to have the highest continuous horsepower rating of any industrial motor in the world.

The motors driving two reversing blooming mills, one in the Pittsburgh district and the other in the Chicago district, are rated at 7,000 hp. and built with a single motor armature which is supplied from two generators in parallel, forming part of a three-unit set. This is a distinct departure from the usual practice of having several armatures connected in series where units of this size are involved. One of these drives is illustrated on this page. Physically, these 7,000-hp. motors are said to be the largest single-armature, reversing motors yet built. However, a similar unit of 8,000-hp. rating is now under construction for use in a 54-in. blooming mill in the Pittsburgh district. This blooming mill is the largest mill of the kind in the country and likewise its driving motor will upon installation be the largest of its kind.

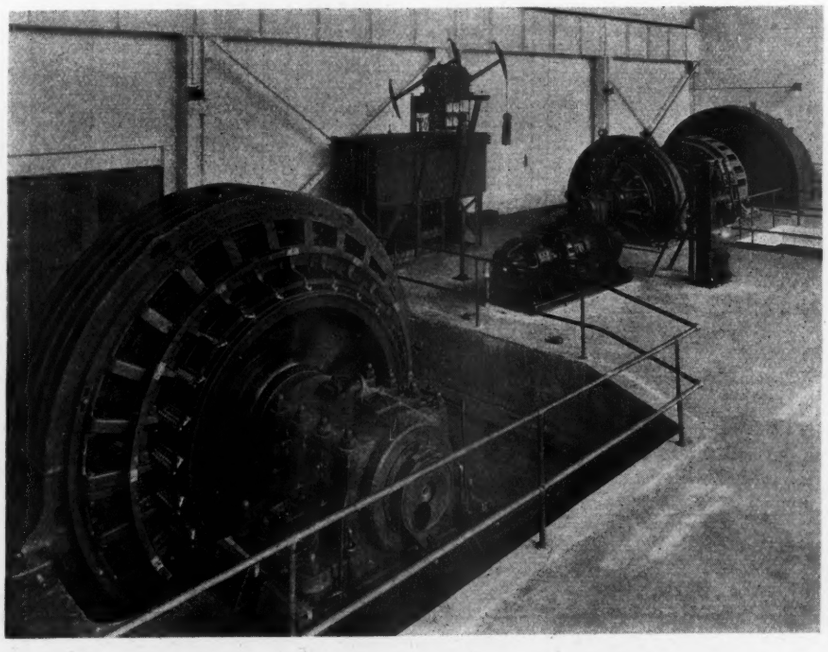
**EVERY TWELVE MONTH** period shows a steady and truly remarkable increase in the application of electricity to the manufacture of iron and steel. The current year has been no exception. Generally speaking, the growth has been along lines that are already well defined and presents little that is fundamentally new. However, there have been many refinements made in the application of electric power, larger capacities of equipment have been used or are contemplated and various other events which go to make the progress accomplished during the year an interesting story. The information presented in this article has been gathered by visits to many of the steel plants in the different steel mill districts, and from interviews with a large number of steel mill engineers and superintendents who are responsible for the maintenance and operation of power-drive equipment. In this article details are given of new developments in the use and application of such equipment and the lines along which men responsible for plant operation are thinking.

Besides the reversing blooming mill drives just mentioned, and the 9,000-hp. synchronous motor for the McKinney Steel Company, another largest motor of its kind is the Kraemer set recently purchased by the Youngstown Sheet & Tube Company for a 21-in. continuous sheet, bar and skelp mill. The induction motor of this set is rated at 7,500 hp. and regulating equipment is provided for adjusting the speed from 250 to 134 r.p.m.

A new type of double range Scherbius drive, apparently the first of its kind, will be installed by the Trumbull Steel Company in its 16-in. hot strip mill. The set is rated at 5,000/4,000/3,000 hp., 450/360/270 r.p.m. The unusual feature of the set lies in the regulating set, which will consist of two machines each rated at 480 kva., 514 r.p.m., a synchronous motor rated at 1,175 hp., 514 r.p.m., and an 18 kw. exciter for supplying excitation to the synchronous motor field. The synchronous motor will replace the usual induction motor, thus providing operation at the maximum possible power factor. The two regulating machines allow a higher speed to be used for the set, each unit being one-half the required capacity. A further advantage is that, by the use of this equipment, a much lower secondary current is developed in the main motor, permitting the use of smaller contactors and resistors of lower current capacity, making the installation work less difficult.

Should it be necessary to remove one regulating machine from the group, the electrical circuit to that unit can be removed and suitably connected; three of the collector rings will be shorted and the equipment will operate with one regulating machine, one-half the total regulation being thus obtained both above and below synchronous speed.

Another interesting development brought out by one manufacturer is the frog-leg winding for direct-current machines, which is said to remove the previous limitations on these machines due to difficulties of



**Largest single armature reversing motor that has been installed up to the present time.**

The installation of this 7,000-hp. reversing motor has just been completed at the new blooming mill of the Wisconsin Steel Co., which is shown on the opposite page. The single armature motor at the left is supplied with 600-volt direct-current power from two generators in parallel forming part of the three unit flywheel motor-generator set shown at the right.

commutating heavy or rapidly fluctuating loads, and now enables them to offer machines which are reported to have commutating qualities beyond anything previously built.

An interest in dry-type air cleaners for use in cleaning the ventilating and cooling air for main drive motors, was expressed by some operators. So far, wet washers have been used almost exclusively for this class of service.

### Changes in Auxiliary Drive Equipment

The use and application of auxiliary motors for steel mill service has been almost standardized. There is, however, a distinct tendency to use synchronous motors wherever possible on auxiliary drives requiring constant speed. This has been caused by a desire to improve power factor conditions or to maintain the good power factor that the plant happens to enjoy. To meet this demand synchronous motors with improved starting and operating characteristics have been developed.

Continued interest is expressed in ball and roller bearings not only for auxiliary motors in the mill, but on other parts of the drive. One of the pioneers in the use of ball and roller bearings in steel mills now has 314 sets of these bearings in operation. It is said that this large installation is cutting down the man-hours required for maintaining the motors, as well as showing a saving in oil and repairs over former requirements.

A plant in the Pittsburgh district in purchasing motors for a new mill had the majority of the mill-type motors equipped with roller bearings. Another plant visited was considering the installation of roller bearings on all of the bearings of some cranes that were about to be contracted for. An installation of roller bearings was made on the conveyor belts in the coke plant in another works visited. This greatly reduced the starting torque required of the motors driving these belts, as well as cutting down on the oiling costs. Most steel plants, however, are putting in ball or roller bearings as a repair proposition wherever service conditions or bearing troubles show a need of them.

On the other hand several operators interviewed stated that more attention should be given to improving the sleeve bearing and in using

## Motor-Driven Main Drives Purchased During Past Year

| Company | Mill | Drive | Motors No. | Motors Hp. | Volts | Cycles | R. P. M. |
|---|---|---|---|---|---|---|---|
| Acme Steel Goods Co. | 20-16-in. Strip | Geared | 1 | 1500 | 2200 | 60 | 705 |
| | 20-16-in. Strip | Geared | 1 | 1500 | 600 | dc | 200/400 |
| | 20-16-in. Strip | Geared | 1 | 1800 | 600 | dc | 185/370 |
| | 20-16-in. Strip | Direct | 1 | 1800 | 600 | dc | 185/370 |
| | 20-16-in. Strip | Direct | 2 | 1800 | 600 | dc | 125/250 |
| Bethlehem Steel Co., Lackawana, N. Y. | 35-28-in. Structural | Direct | 1 | 3500 | 700 | dc | 50/120 |
| | 35-28-in. Structural | Direct | 1 | 5000 | 700 | dc | 75/150 |
| Carnegie Steel Co., Homestead, Pa. | 54-in. Blooming | Direct | 1 | 8000 | 700 | dc | 40/120 |
| | 52-in. Structural | Direct | 2 | 7000 | 700 | dc | 50/120 |
| Connors Steel Co. | Hoop | Geared | 1 | 800 | 2200 | 60 | 435 |
| Gary Tube Co. | Seamless Tube | Geared | 1 | 2500 | 6600 | 25 | 247 |
| Inland Steel Co. | 36-in. Rev. Rougher | Direct | 1 | 7000 | 700 | dc | 50/120 |
| Wisconsin Steel Co. | 40-in. Blooming | Direct | 1 | 7000 | 700 | dc | 50/120 |
| | Merchant | Direct | 1 | 3100 | 600 | dc | 70/150 |
| | Merchant | Direct | 3 | 2000 | 700 | dc | 230/460 |
| Kokomo Steel & Wire Co. | 34-in. Blooming | Direct | 1 | 3500 | 700 | dc | 50/120 |
| Lukens Steel Co. | 112-in. Plate | Geared | 1 | 3750 | 2200 | 60 | 500 |
| National Tube Co. | Tube | Geared | 1 | 1800 | 2200 | 60 | 252 |
| Rail Joint Co. | 20-in. Bar | Geared | 2 | 1000 | 2200 | 60 | 710 |
| Central Tube Co. | Pipe | Geared | 1 | 300 | 230 | dc | 500 |
| Ohio Seamless Tube Co. | Pipe | Geared | 1 | 500 | 2200 | 60 | 600 |
| Otis Steel Co. | Cold Roll | Geared | 2 | 375 | 230 | dc | 430/860 |
| Pacific Coast Steel Co. | 10-in. Merchant | Geared | 1 | 1500 | 2200 | 60 | 320/200 |
| Carnegie Steel Co., Youngstown, Ohio. | 12-in. Strip | Geared | 1 | 1125 | 6600 | 25 | 312/187 |
| | 12-in. Strip | Geared | 1 | 1500 | 6600 | 25 | 468/281 |
| | 12-in. Strip | Geared | 1 | 2000 | 6600 | 25 | 625/375 |
| | 14-in. Bar | Geared | 1 | 2000 | 6600 | 25 | 625/375 |
| | 18-in. Band | Geared | 2 | 2500 | 6600 | 25 | 187½ |
| | 18-in. Band | Geared | 1 | 2200 | 6600 | 25 | 275/225 |
| Seneca Iron & Stee lCo. | Hot Sheet | Geared | 1 | 1700 | 440 | 25 | 250 |
| Buffalo Steel Co. | Rail Splitter | Geared | 1 | 400 | 4400 | 25 | 750 |
| Bethlehem Steel Co., Sparrows Point, Md. | 46-in. Slabbing | Direct | 1 | 7000 | 650 | dc | 50/100 |
| | 10-in. Rod | Geared | 1 | 4000 | 6600 | 25 | 375 |
| Kawasaki Dockyard, Japan. | Sheet | Geared | 1 | 1200 | 2200 | 60 | 240 |
| American Nickel Corp. | Cold Sheet | Geared | 1 | 1000 | 2200 | 60 | 450 |
| Youngstown Sheet & Tube Co., Indiana Harbor, Ind. | 21-in. Skelp | Geared | 1 | 3600 | 2200 | 60 | 290/156 |
| | 21-in. Skelp | Geared | 1 | 7500 | 2200 | 60 | 250/134 |
| | 21-in. Skelp | Direct | 3 | 2000 | 600 | dc | 85/165 |
| Tennessee Iron & Coal Co. | Sheet | Geared | 1 | 2000 | 6600 | 60 | 600 |
| Inland Steel Co. | 8-in. Continuous | Direct | 1 | 1500 | 600 | dc | 50/80 |
| | 8-in. Continuous | Geared | 1 | 1800 | 600 | dc | 200/400 |
| | 8-in. Continuous | Direct | 1 | 800 | 600 | dc | 350/750 |
| | Sheet | Geared | 1 | 2500 | 2200 | 25 | 300 |
| Colorado Fuel & Iron Co. | Rod | Direct | 1 | 1500 | 600 | dc | 450/550 |
| | Rod | Geared | 2 | 3000 | 6600 | 60 | 450 |
| | Rod | Geared | 2 | 1000 | 6600 | 60 | 720 |
| | 14-in. Merchant | Direct | 1 | 1500 | 600 | dc | 100/150 |
| | 14-in. Merchant | Direct | 1 | 750 | 600 | dc | 150/250 |
| | 10-in. Merchant | Direct | 1 | 1500 | 600 | dc | 200/300 |
| | Rail Mill | Geared | 1 | 2000 | 6600 | 60 | 450 |
| | Rail Mill | Geared | 1 | 3000 | 6600 | 60 | 450 |
| | Rail Mill | Geared | 1 | 1200 | 6600 | 60 | 450 |
| Inland Steel Co. | 24-in. Bar | Direct | 1 | 3000 | 750 | dc | 70/150 |
| McKinney Steel Co. | Continuous Billet | Direct | 1* | 9000 | 6600 | 25 | 107 |
| Bethlehem Steel Co., Steelton, Pa. | 28-in. Rail | Geared | 1 | 4000 | 6600 | 25 | 375 |
| | 35-in. Rail | Direct | 1 | 3500 | 650 | dc | 50/100 |
| Trumbull Steel Co. | 16-in. Hot Strip | Geared | 1 | 5000 | 2200 | 60 | 450/270 |
| Thomas Sheet Steel Co. | Cold Rolls Sheet | Geared | 1 | 400 | 2300 | 60 | 360 |
| Otis Steel Co. | Jobbing Plate | Geared | 1 | 2000 | 2200 | 25 | 214 |
| International Nickel Co. | Cold Rolling | Geared | 1 | 750 | 230 | dc | 300/600 |
| Kansas City Bolt & Nut Co. | Sheet Mill | Geared | 1 | 1500 | 2200 | 60 | 295 |
| Gary Tube Co. | 16-in. Skelp | Geared | 1 | 350 | 230 | dc | 500 |
| | 16-in. Skelp | Geared | 1 | 550 | 6600 | 25 | 370 |
| | 16-in. Skelp | Direct | 1 | 2500 | 6600 | 25 | 295 |
| | 16-in. Skelp | Direct | 1 | 2500 | 6600 | 25 | 146 |
| | 16-in. Skelp | Direct | 1 | 3000 | 6600 | 25 | 184 |
| | 14-in. Skelp | Geared | 1 | 1500 | 6600 | 25 | 491 |
| | 14-in. Skelp | Geared | 1 | 1000 | 6600 | 25 | 293 |
| | 14-in. Skelp | Geared | 1 | 2000 | 6600 | 25 | 294 |
| | 14-in. Skelp | Direct | 1 | 1250 | 6600 | 25 | 294 |
| | 14-in. Skelp | Direct | 1 | 1000 | 6600 | 25 | 209 |
| Bethlehem Steel Co., Johnstown, Pa. | 18-14-in. | Geared | 2 | 3000 | 250 | dc | 150/300 |
| | 18-14-in. | Geared | 2 | 1500 | 250 | dc | 150/300 |
| Bethlehem Steel Co., Buffalo, N. Y. | 18-14-in. | Direct | 1 | 3000 | 250 | dc | 150/300 |
| | 18-14-in. | Direct | 1 | 1500 | 250 | dc | 150/300 |
| Bethlehem Steel Co., Johnstown, Pa. | 12-10-in. | Geared | 1 | 2000 | 250 | dc | 200/600 |
| Johnstown, Pa. | 12-10-in. | Geared | 1 | 1700 | 250 | dc | 250/500 |
| | 12-10-in. | Direct | 1 | 900 | 250 | dc | 425/640 |
| | 12-9-in. | Geared | 2 | 1000 | 250 | dc | 200/480 |
| | 12-9-in. | Direct | 1 | 500 | 250 | dc | 250/600 |
| American Sheet & Tin Plate Co. | Steel | Geared | 1 | 1250 | 6600 | 25 | 300 |
| Gary Tube Co. | Skelp | Direct | 1 | 4500 | 750 | dc | 120/255 |
| Indianapolis Steel Casting Co. | Bore | | 1* | 500 | 2200 | 25 | 450 |
| National Tube Co., Lorain, Ohio. | Piercing | Geared | 1* | 1000 | 6600 | 25 | 375 |
| | Piercing | Direct | 1* | 800 | 6600 | 25 | 107 |
| Phoenix Iron Co. | 36-in. Blooming | Direct | 1 | 3500 | 700 | dc | 50/120 |
| Youngstown Sheet & Tube Co., Youngstown, Ohio. | Seamless Tube | Direct | 1 | 3000 | 600 | dc | 40/100 |
| | Seamless Tube | Geared | 3 | 650 | 600 | dc | 225/400 |
| | Seamless Tube | Direct | 1 | 3000 | 600 | dc | 125/200 |

*Indicates Synchronous Motor.

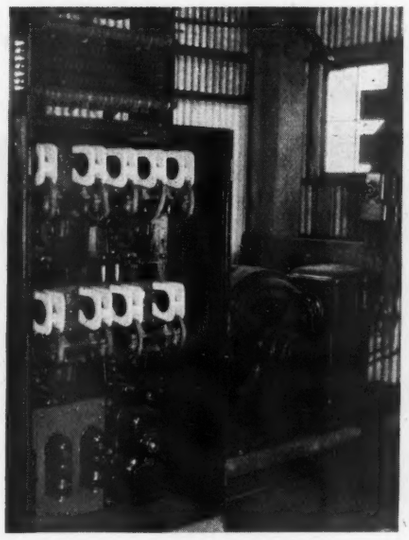
For drives purchased prior to Aug. 1, 1924, see page 410, of the September, 1924, issue of INDUSTRIAL ENGINEER

the correct grade of bearing metal properly heated and poured. Some of them felt that a great deal of the trouble experienced by some operators was due to poor workmanship in making their bearings in their own shops. The leading motor manufacturers have made radical improvements in the sleeve bearings used in their motors, which are said to greatly reduce the oil troubles that have been experienced.

### Use of Flexible Couplings on Auxiliary Drives

An interesting tendency is noted in the greatly increased use of flexible couplings on steel mill auxiliary drives. In a new blooming mill in the Chicago district, flexible couplings were used on practically all of the auxiliary drives. These couplings were not used on the cranes, however. In new mills at one plant in the Pittsburgh district, the engineer interviewed stated that 80 per cent of the auxiliary drives were equipped with flexible couplings. In a new blooming mill in this same district, the operator talked with said that flexible couplings were used in every possible case.

Several reasons were advanced by the superintendents interviewed for the adoption of these couplings. The electrical superintendent of one plant visited stated that he had decided to use the flexible couplings because he was thereby able to do away with back-geared, mill-type motors and thus keep all of the gears in one housing instead of two, as well as reduce the number of types of motor frames required. Reasons advanced by other engineers interviewed are: the reduction of gear shock on the motor and the insuring of proper alignment of motor pinion and driven gear.



**Here is a newly developed automatic starter for a synchronous motor.**

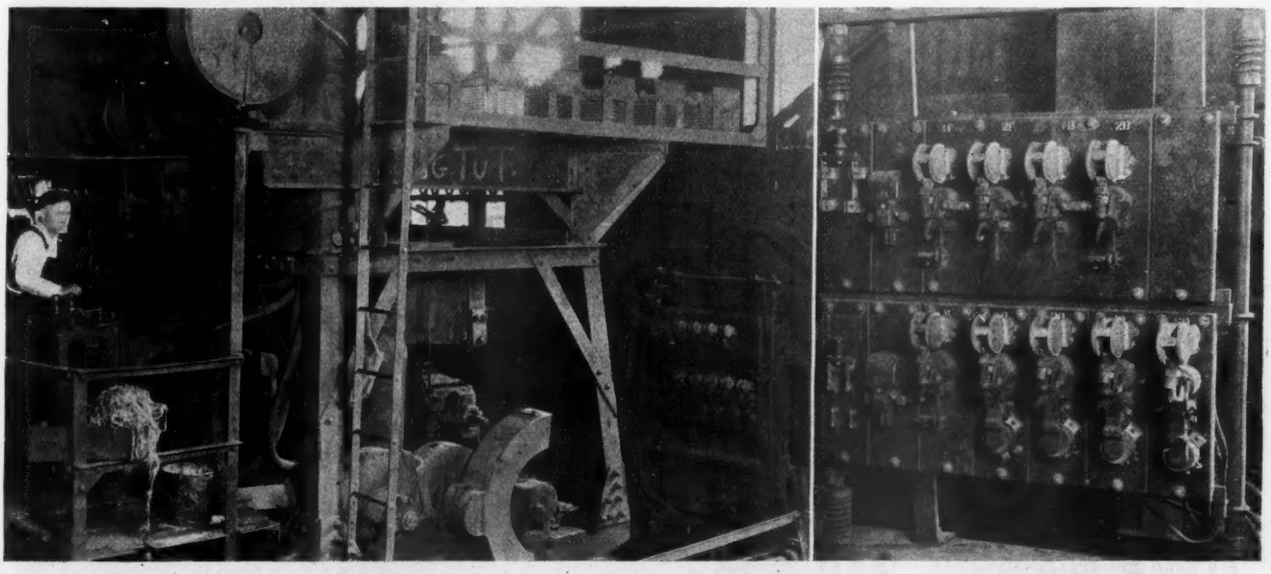
The direct-current field excitation is automatically applied under the control of a timing relay after the motor has been accelerated almost to synchronous speed. Two sets of overload relays are used; one set, which is set for tripping at a lower current, disconnects the magnetic clutch between the motor and the drive and the other set disconnects the motor from the line.

**The increased use of time-limit acceleration on auxiliary control is an interesting tendency.**

The controller on the bridge motion of this soaking pit crane controls two 50-hp. motors in series. Inductive time-limit acceleration is used. The control panel is mounted on the bridge end-girder in the right background. A close up view of the panel is shown at the right. The first four contactors at the right in the lower section of the board are the accelerating contactors. Notice that these contactors have two operating coils that oppose each other for the contactor armature is hinged between the two coils. The function of these coils is described in the accompanying article.

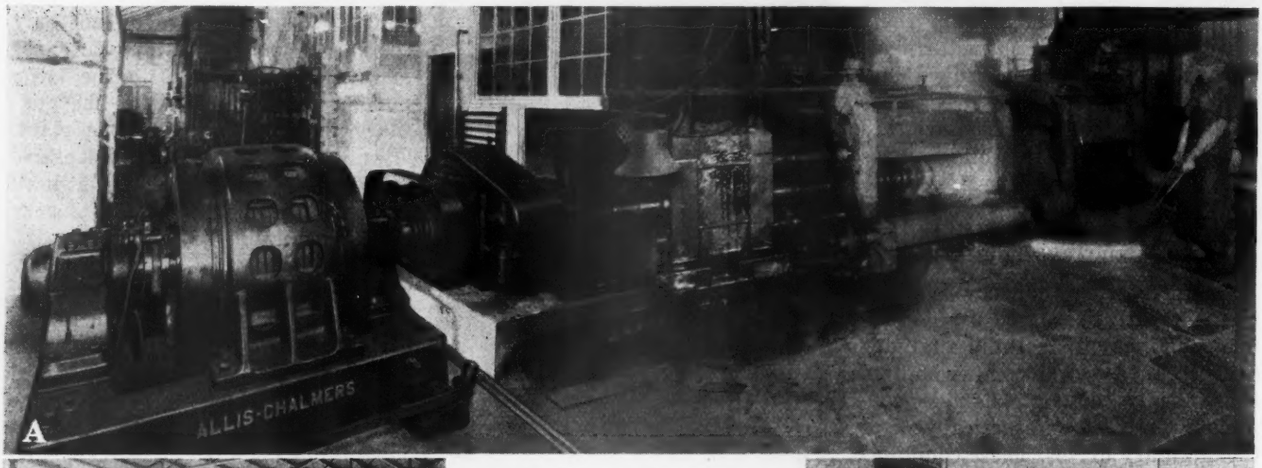
Decidedly more attention is being paid to the gears used on not only the large gear reduction units for main drives, but also on the large number of gears used for the auxiliary drives throughout the plant. Gears as used in auxiliary drives are following the developments that have been made in the large-capacity gear reduction units. In place of the sheet-iron cover and the use of heavy grease on the gears of auxiliary drives we find many of them totally enclosed in oil-tight, cast housings. The gears run in oil and force-feed lubrication is often provided. The use of heat-treated gears and pinions is increasing. Several plants visited maintain their own heat-treating departments. The use of herringbone gears on auxiliary drives has been considered and in one instance has been tried.

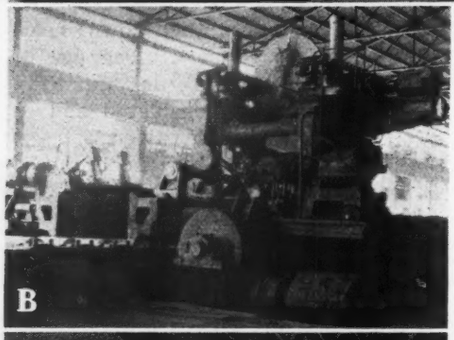
An increase in the use of speed reducers in steel mills was also noted. These have found greatest application on various kinds of conveyors, such as pipe conveyor chains, small roll conveyors, pipe pushers and the like. One operator stated that he was using them because they were very compact and would fit into crowded quarters, are totally enclosed, well lubricated and he expected them to have a long life with small maintenance. An engineer in the Chicago district was using them because the space he had available was very cramped and he needed a tightly-enclosed reduction because of the dirty location.

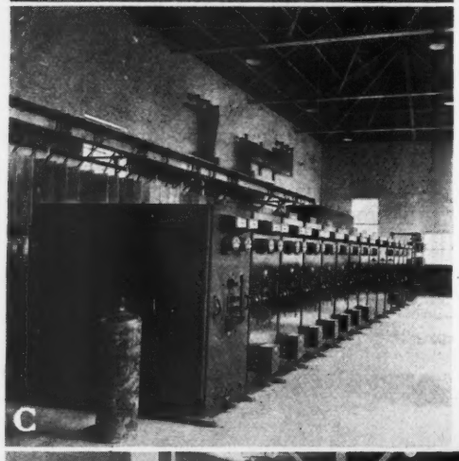


# Seven Applications of Power Service in Steel Mills

## *Illustrating Present Trends in the Industry*




A—Synchronous motor geared to the main rolls in a roughing mill of the Atchison, Topeka & Santa Fe R. R. The motor is rated at 500 hp. and has a speed of 450 r.p.m.

B—Flexible couplings are used on all of the auxiliary drives of this blooming mill recently completed by the Campania Cia Siderureica Del Mediterraneo, Sagunto, Spain.

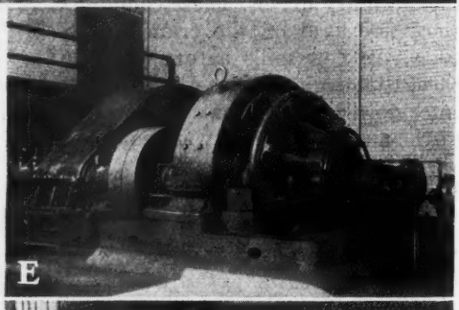
C—Truck-type switchboards are finding increased favor in steel mills. This one is installed in the plant of the International Nickel Co. at Huntington, W. Va.

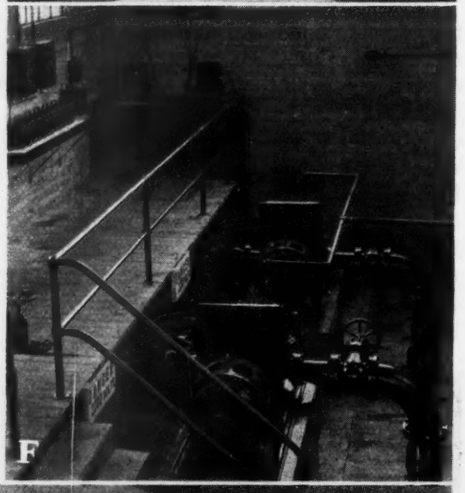
D—Motor room of the new 40-in. reversing blooming mill at the Lackawanna plant of the Bethlehem Steel Co.

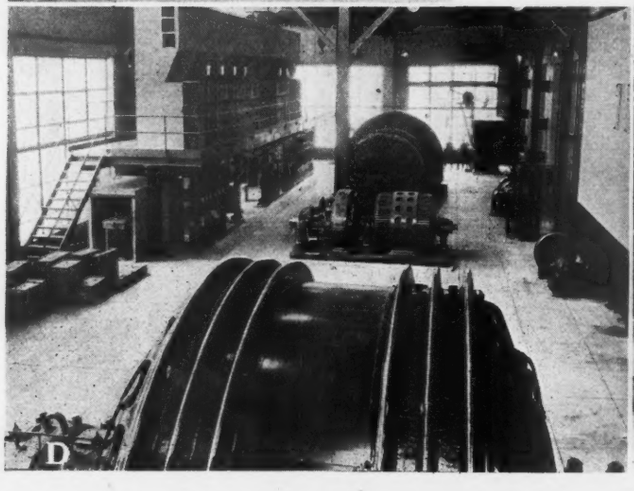
E—A 3,000-hp., 325/485-r.p.m., 600-volt, d.c. motor driving the 24-in. structural mill of the Phoenix Iron Co. through a herringbone gear reduction. The motor is supplied with d.c. power from a flywheel motor-generator set.

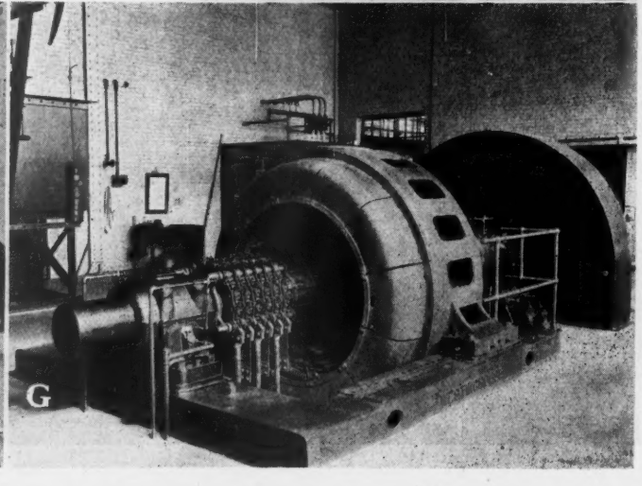
F—Automatic high-voltage compensators installed in the pump house of a steel plant.

G—A 2,500-hp., 514 r.p.m., wound-motor induction motor driving a 22-in. bar mill through a high-speed flywheel and a herringbone reduction gear, in the plant of the Phoenix Iron Co. This motor is arranged so that speed adjusting auxiliaries can be added at some future time.



Development of control equipment for steel mill service is by no means at a standstill. Probably one of the outstanding trends is expressed in the keen interest displayed by many operators in time-limit acceleration. Current-limit acceleration has become almost an accepted standard form and many operators expressed satisfaction with its performance. However, the development of new types of time-limit devices has stimulated new interest in this form of acceleration.

### Trends in Use and Installation of Steel Mill Control

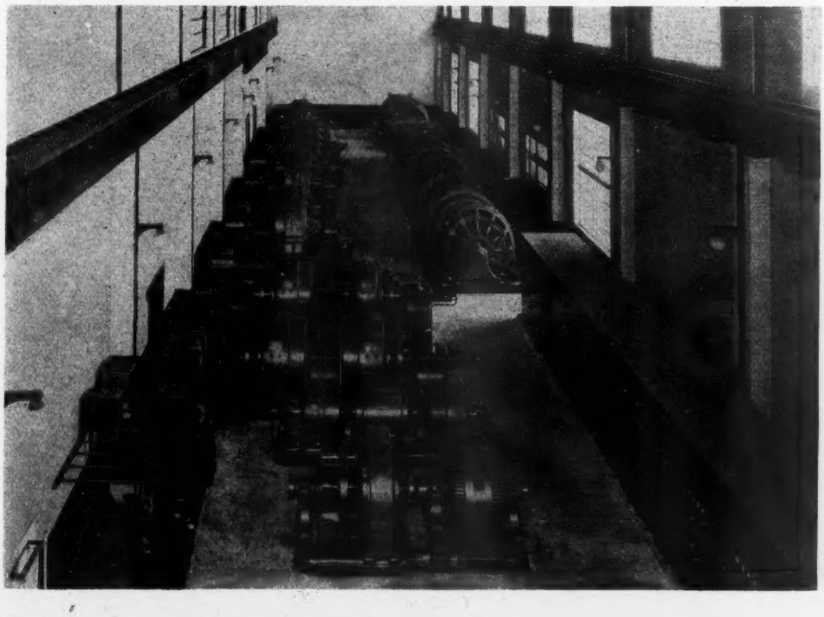
In one system the time interval between the closing of successive accelerating contactors is secured by an ingenious application of the well-known principle that when a constant, direct-current potential is applied to a circuit containing inductance, an appreciable time elapses before the current reaches its maximum value. On this particular type of control, the accelerating contactors have both a shunt closing coil and a shunt holding-out coil, both of which act upon the same armature, as is shown in the right-hand illustration at the bottom of page 409. On the back of the controller is mounted a transformer having two series windings, the motor being connected to the middle or common point. The motor connections are so arranged that for each successive accelerating point, one or the other of these windings serves as the primary and the main motor current passes through this coil. The connections are arranged so that the coil which does not carry the motor current is connected to the holding-out coil on the next accelerating contactor, and by adjusting the air gap on the accelerating contactor, the time of closing can be varied between definite values which depend on the stored energy in the magnetic circuit of the transformer, the design of the holding-out coil, and the adjustment of the contactor air gap.

This form of time-limit acceleration is known as the inductive type. Another form, known as the magnetic type secures the time element of acceleration by the delay in building up or down of a magnetic field. When the relay coil is short-circuited, a definite time is required for the flux to decrease to a point permitting the release of the relay armature. This armature is forced out by a spring of adjustable tension which, together with other features, gives a timing range of 0.2 to 2.0 seconds. Once adjusted, this timing is said to remain constant under all operating conditions. Current-limit is provided for plugging when reversing, while the time-limit is used for acceleration.

In talking with many steel mill operators it was found that several installations of both types had been made, which are being watched with great interest.

**Truck-type switchboards are finding increased favor in many steel plants.**

This type of switching is used for the alternating-current end of 13,500 kw. in synchronous motor-generator sets in the recently completed 14-in. continuous mill of the Woodlawn Plant of the Jones & Laughlin Steel Corporation. In this same motor room there are 14,600 hp. in 600-volt, direct-current, main roll motors.



Another tendency lies in the arrangement of groups of the more important panels so that a spare panel may be switched into use in case a failure should take place on any panel in that group. Recent installations of this arrangement have been made by the Westinghouse Electric & Mfg. Co., the General Electric Company and the Cutler-Hammer Mfg. Co. A typical installation of this system at the Lackawanna plant of the Bethlehem Steel Company is shown in the illustrations on page 414. This group of panels controls the auxiliary motors for a 40-in. blooming mill. At the bottom of 11 of these panels are four-pole, double-throw switches that are used for transferring the motor circuits from the regular panels to the spare panel. A small drum switch is mounted on each regular panel, which is used to transfer the master switch circuits from the regular panel to the spare panel.

Another installation of this arrangement of control is shown on page 412. This installation consists of 20 panels. One panel serves as a spare for two regular panels controlling motors driving the manipulator lifts, a second panel serves as a spare for five other panels, including the main tables, sideguards and screw downs, while a third panel is a spare for the remaining nine panels. In the case of the last two spare panels just mentioned, the panels may be called upon to control either of two capacities of motors. This is taken care of by the multipole switch in the bottom section of the spare control panels. By manipulating this switch the resistors are connected in parallel to take care of the larger-sized motor.

With this type of installation, control trouble can cause a delay of only a few seconds, for the defective panel may be cut out and the spare panel put in service almost instantly.

At one plant this idea has been carried still further by using what is known as plug-type master switches. By loosening four wing nuts, a master switch may be removed and another one inserted in its place. A plug-type connection is used for connecting the master switch terminals to the wires leading to the control panel.

On the other hand, one engineer in discussing this subject with the writer stated that he did not favor this arrangement of control because

in his experience control failures are very few and usually give ample warning of their approach. He felt that each controller should be selected and designed particularly for the application on which it is to operate, rather than use standard controllers on all jobs that were somewhat similar.

In order to cut down operating costs by reducing the number of men required, automatic operation is being used more and more. In the soaking pits of a new blooming mill in the Pittsburgh district, the control is so arranged that the soaking pit crane operator opens and closes the soaking pit covers, lifts out the ingot with his crane, places the ingot in the buggy and starts the buggy on its way to the transfer car. This eliminates the doorman and buggy operator formerly required. As the buggy approaches the point where it meets the transfer car it automatically slows down to a stop and if the transfer car is in place the ingot is automatically dumped into it. If the transfer car is not in place the ingot is held until the car arrives. At this same mill and also at another blooming mill nearing completion in the Chicago district, the large reversing motor driving the main rolls is controlled from a foot-operated master, thereby cutting down the number of men required in the pulpit from three to two.

In the blast furnace blower house of a large mill in the Chicago district this same thought has been carried out by using a centrally-located control point for all of the blast furnace turbo-blowers. The control consists of remote-controlled, motor-operated governors on the turbines and motor-operated valves. Control for three or more blowers is located at one place so that they may be controlled simultaneously by one engineer, thereby resulting in a reduction in the number of engineers required in the blower room. Special telephone connections are made from each blast furnace to this central control point. Verbal orders as to pressure, checking, and the like are telephoned to and executed by the one engineer.

### More Substantially Constructed Control Houses

In all of the new mills visited a marked trend was noticed towards the more substantial housing of control equipment. The favored construction is to place the control in a centrally-located brick house adjacent to and overlooking the main part of the mill. In a new blooming mill in the Chicago district a two story brick enclosure is built just opposite the mill runout tables. The first story is used as a motor inspector's shanty and provides space for his tools, miscellaneous supplies, and spare equipment. It also provides a convenient location for bringing in the power lines and conduits coming from the auxiliary drives to the control panels which are located on the second floor. The panels are located in two rows facing each other with at least 5 ft. of room behind the panels so that a man may do any necessary repair work in comfort and safety. There is a large window so located in the wall that most of the motors out in the mill can be seen from the control house. Conduits to auxiliary motors go down through the floor. Power is fed to the panels from a bus located over the panels and under the resistor balcony. The resistors are placed in two balconies in rows at right angles to the panels and each resistor frame is so mounted that it may be removed from the stack without disturbing the others. Walkways are provided between the rows of resistors so that each resistor is accessible from either side. This arrangement of resistors is illustrated on page 413.

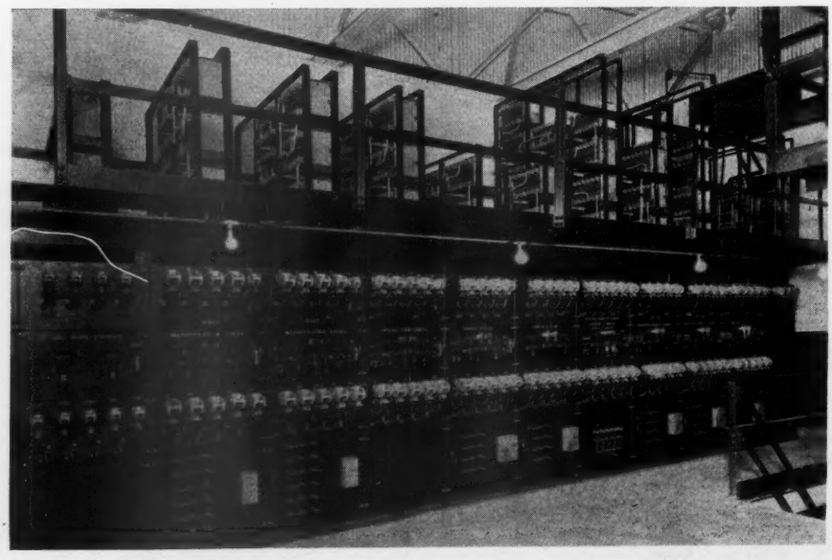
The idea behind the whole installation is that if a tight enclosure is provided, the operating conditions will be less severe and the maintenance much easier. Also, if all parts are accessible so that they can be reached in safety, the quality of inspection received will be much better. When a failure actually does take place it will be quickly corrected, inasmuch as the room and facilities are provided for making quick repairs or changes.

As mentioned before in this article, new uses and applications are being found for synchronous motors. Owing to this demand several manufacturers have developed automatic starters for use on these motors. Push button control is provided and the direct-current field excitation is automatically applied under the control of a timing relay after the motor has been accelerated almost to synchronous speed. An installation of this type of control is shown on page 409.

An interesting innovation was made in the control for the blast furnace pump motors in a large plant in the Cleveland district. These pumps are important applications and must at the same time have proper overload protection; hence they are connected direct to the power house bus so as to insure continuity of service.

**Provision for quickly switching in a spare panel in an emergency is an innovation in several mills.**

In this control house of the new blooming mill of the Wisconsin Steel Co., there are 20 panels arranged in two rows facing each other. One panel is a spare for two regular panels, a second panel is a spare for five other regular panels and a third panel (the one at the extreme left) is a spare for nine other regular panels. The spare panel at the left is arranged for two capacities of motors. Switching from one size to the other is obtained by the multi-pole switch at the bottom of the spare panel. This parallels sections of the resistance. Transfer of the main motor connections from the regular panel to the spare is effected by the large multi-pole switches in the bottom sections of the regular panels. The master switch circuits are transferred by means of the small switch in the box to the right of each large transfer switch.



Because the ordinary compensator does not have sufficient rupturing capacity it was necessary to use oil switches of proper rupturing capacity in connection with each pump. This made the layout rather expensive.

To reduce the cost, and because the motors were seldom started and stopped, it was decided to use only one auto transformer. This is connected to the 2,300-volt supply by an oil switch. The auto transformer supplies low-tension starting voltage to a bus which is carried to each motor. Connecting this starting bus to each pump motor is a non-automatic oil switch that is used for starting duty only. The 2,300-volt supply is connected to each motor through an automatic oil switch equipped with overload relays. The starting and running switches have the usual mechanical interlocks and, in addition, interlocks are provided which prevent starting more than one motor at a time. This provides selective protection on each motor and eliminates the necessity of large auto-transformers for each motor.

The question of whether to use compensators or primary resistance starters on low-voltage, squirrel-cage motors is still a live one. One engineer interviewed stated that he was using only primary resistance starters, while others expressed a preference for automatic compensators. The general opinion, however, seems to be that there is a field for both; that some applications are more adapted to compensators while others are more suited for primary resistance starters.

A very interesting installation of about 1,500 enclosed circuit breakers has been made in one steel plant in the Chicago district. Every motor in the plant is given overload protection by means of an enclosed circuit breaker installed in its vicinity. An unusual feature is that the circuit breakers are made with removable elements. The leads coming to the circuit breaker are permanently connected to a terminal board which has contact blocks on the face of it which connect to the circuit breaker proper. The circuit breaker element is mounted on a separate panel which can be quickly removed by releasing the lever which holds the steel enclosing cover in place. Hence in case of a failure of a circuit breaker, replacement with a new circuit breaker element is merely a matter of seconds.

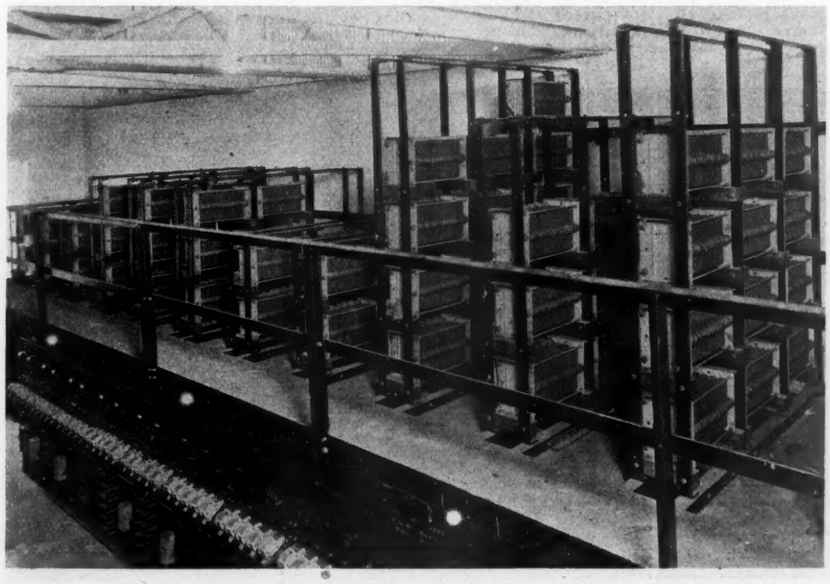
Reduction of spare parts by standardizing on types and sizes of resistor frames has been worked out exceedingly well in a new blooming mill in which only four different resistor frames are used.

Many operators expressed interest in a new type of resistor that has been recently developed. This resistor consists of a high-resistance alloy ribbon, wound on edge, and mounted on a steel-reinforced porcelain support that passes through the entire length of the unit. Two simple forms of clamps provide the facilities for making connections at the ends or at any desired point in the resistance.

Another new development that will be of interest not only to steel plant electrical superintendents but also to the electrical men of all industries is the line of threadless conduit fittings that have been recently placed upon the market. No threading of conduit is required with this fitting, the conduit being held to the fitting by an ingenious clamping arrangement by which the fitting actually bites into the conduit. The fittings are made of malleable iron thereby preventing breakage.

**Here is an unusually well arranged resistor balcony.**

This is a close up view of the resistor stacks for the control panels shown on the opposite page. Each stack of resistors is for the panel directly underneath it. All resistors are accessible on both sides and are mounted independently in the stack so that each resistor frame may be removed without disturbing the others. Under each stack is a large opening for ventilation and through which the resistor leads pass to the control panel. An arrangement such as shown here cannot help but receive frequent careful inspection, good maintenance and rapid repair.



## Tendencies in Power Generation and Distribution

The steam turbine continues to hold first place as a prime mover in the generation of power in the steel plant. During the past year 14 units aggregating over 100,000 kw. and which were sold to steel plants, is evidence of a substantial increase in generating capacity.

On the other hand, there has been a decided increase in the amount of purchased power used in all steel districts. Most operators feel that the steel plant should generate power only to the extent of the waste heat available in the form of blast furnace gas and the like. Also, as the size and reliability of the public service companies have increased, steel mill operators have acquired more confidence in their ability to furnish continuous service.

Some interest is shown in the interconnection of steel plant and public utility generating stations for the purpose of exchanging power. This is being worked out successfully in several instances, but so far it cannot be said to be a general trend.

At the present time power factor is receiving more careful consideration in many steel plants. This has been due to a closer study of operating costs and the need for voltage improvement in power systems. Also, central stations are giving this subject more attention than in the past and are more strict in their enforcement of the bonus and penalty clauses regarding power factor. However, many of the plants visited have their power factor under con-

trol. One plant visited has even gone so far as to automatically increase the field excitation on some of the synchronous motors driving air compressors, during periods of high maximum demand.

This plant has an average power factor of 93 per cent, which is very satisfactory indeed. All operators interviewed stated that they were using synchronous motors in every possible application. This has been one reason for the large number of synchronous motor-generator sets used, as compared to rotary converters, for obtaining direct current in steel plants.

As would be expected, the steel mills are following the developments that have become established practice for power houses in the central-station field. The main tendencies are the use of higher steam pressures, better combustion of blast furnace gas under boilers, and centralization of power houses, together with the use of larger units.

Greater interest is being shown in switching as applied to power houses and substations. This has been caused by connecting to utilities having a large power capacity and by the use of larger steel plant power houses. Hence, switches having a much greater interrupting capacity than formerly considered necessary are now required. Many plants have found it necessary to exchange low interrupting capacity circuit breakers for larger ones.

### Developments and Trends in Substations

During the past year there has been an increased tendency toward the use of automatic substations. One plant in the Pittsburgh district has just purchased two equipments for controlling synchronous motor-generator sets. The Wheeling Steel Corporation at Martins Ferry, Ohio, has purchased automatic equipment for two motor-generator sets. In discussing this subject with the writer one engineer stated that he would install automatic equipment in any new substations that might be put in and had considered putting in such equipment in his present substations. Inasmuch as he had been able to get substation operators to do quite a little bench work in the substation he has been able to reduce the cost of operating the substation to such an extent that he had for the time being given up the idea of using automatic control in these stations.

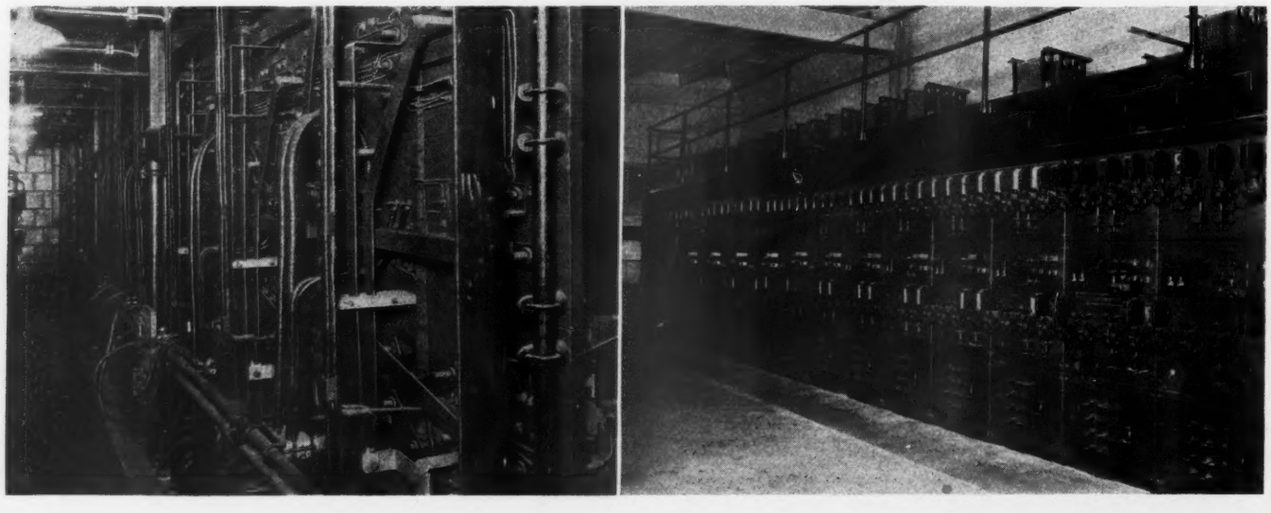
The increase in the use of automatic substation control has been due primarily to the extreme reliability of operation together with the operating saving compared to manual control.

Another interesting tendency along the lines of automatic substations is the automatic pumping station. One company is installing such a station for pumping water for its blast furnace. The pumps are a very important adjunct to the blast furnace; consequently automatic operation is a step in advance. Among other things this installation will have protection for all bearings, a priming pump, and automatic starting of pump when primed. Another engineer interviewed stated that he was considering a similar installation.

There is a very decided increase in the use of truck-type switching equipment. Many operators are swinging toward this type of switchboard because of the greatly increased safety and the ease of maintenance and repair. One objection to truck-type boards has been their increased cost over the usual type of switchboard. However, several electrical superintendents interviewed stated that when the cost of installation of both types was considered, there was not so much difference in total cost.

One large pipe manufacturer in the Chicago district is installing one of the largest truck-type boards that was ever built. Another plant in this district is putting in 12 such boards, two of which are for operation on 12,000 volts and the remainder on 2,300 volts. A notable installation of truck-type switchboards is shown in the illustration on page 411. Several motor-generator sets are controlled from these boards. A feature of this installation is that the starting and running boards for the motor-generator sets are separate and mounted on different trucks. Hence, after a motor-generator set has been started, its starting board can be removed for maintenance work or for use on some other motor-generator set in case of necessity.

*(Please turn to page 457)*



**Another example of the trend towards better control houses for auxiliary control equipment.**

These twelve panels control the auxiliary motors of the new 40-in. blooming mill at the Lackawanna plant of the Bethlehem Steel Co. The fourth panel from the left is a spare which can be switched in place of any other panel by means of the transfer switches located on the bottom sections of the regular panels. Notice that the resistors are located in a balcony over the panels. At the left is a rear view of this panel. All leads to the motors and master switches leave through conduit in the floor. The resistor leads are the leads carried vertically and held by clamps fastened to the bottom of the balcony. Ample working space is provided behind the panels.

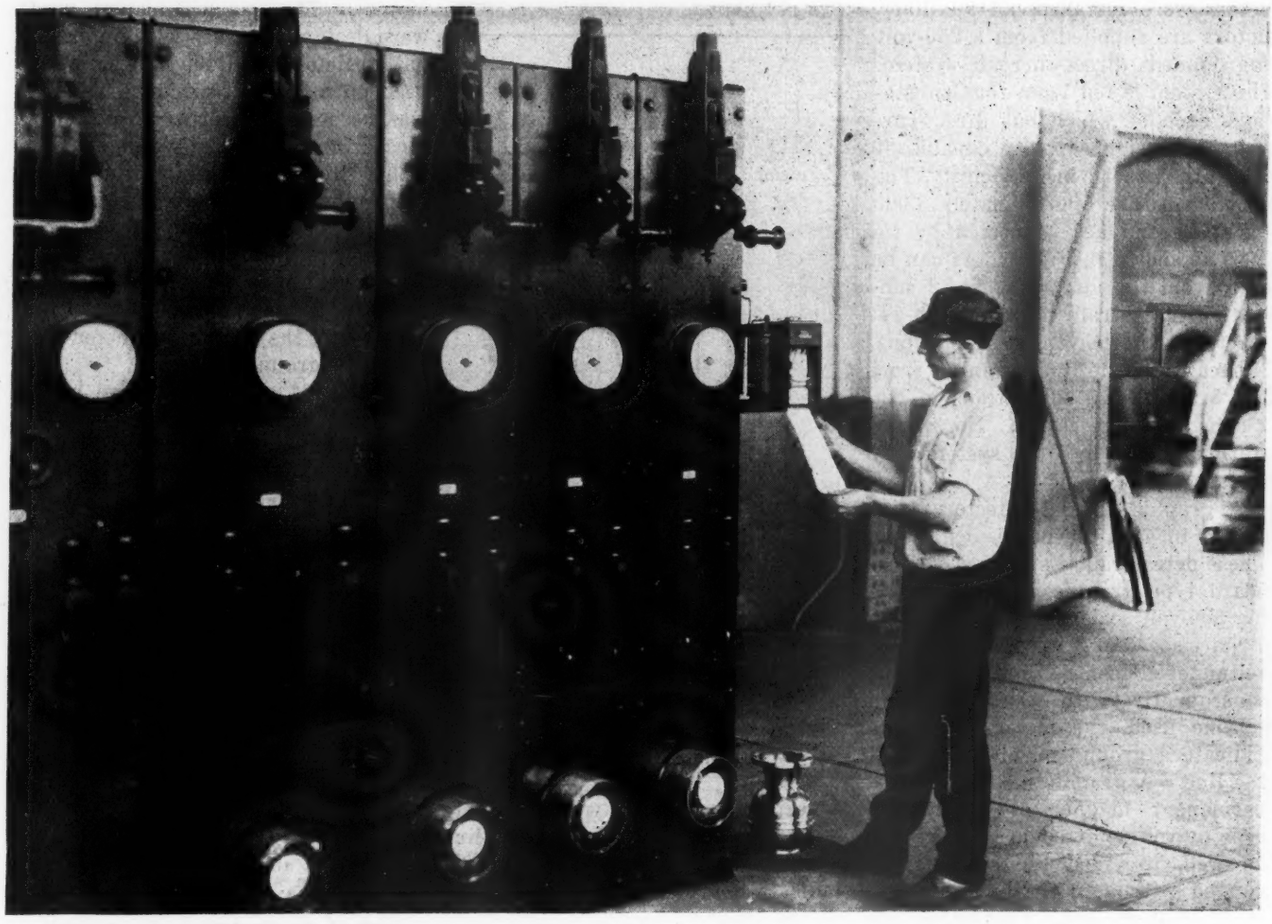


**Fig. 1—Inspection of the chart from the graphic meter tells what kind of grounds are on the system and aids in locating them.**

A standard graphic voltmeter is mounted on iron brackets at the end of the switchboard. The meter is connected to the bus behind the switchboard through two external resistors as is shown in Fig. 2. The resistors may be seen mounted immediately to the left of the graphic meter and on the brackets supporting the meter.

*How One Progressive Industrial Plant Is*

# Using Graphic Meters for Detecting Grounds

## *On Its Direct-Current Distribution System and Power Service Equipment, Together With Details of the Installation, Typical Charts From the Graphic Meters, and the Results Obtained*

By R. H. BAHNEY

*Chief Electrician, The Central Steel Company, Massillon, Ohio*

**USING GRAPHIC meters for detecting grounds has resulted in a reduction of 26 per cent in the delays on the direct-current equipment in a steel plant having 12,285 connected horsepower of direct-current motors and has also shown a material saving in the maintenance cost on these motors and other power service equipment. In this article Mr. Bahney tells the details of the method he uses and shows how he interprets the charts from the graphic meters so as to locate the grounds.**

ALL who are familiar with electrically operated plants, especially with ungrounded, direct-current systems, will realize the difficulties and loss of time frequently resulting from the failure of maintenance men to promptly locate and clear grounds that appear on the power distribution lines. The graphic meter system for detecting grounds, which is described in this article, was installed to cut down the delays resulting from these troublesome grounds. The graphic meters make a chart record of any grounds that appear on the system, thereby giving early notice of any impending ground trouble. Analysis of the chart will show the character of the ground and thus greatly aid in locating the point of failure. One of the main advantages derived is the fact that the maintenance men know that we have a continuous check on their equipment day and night. Foremen are required to report to the substation operators where the grounds were located, thereby accounting for every ground shown on the chart. Consequently the responsibility for the locating and clearing of grounds is definitely fixed.

In the plant where the graphic

meters were installed, all auxiliary motors are supplied from a 250-volt ungrounded direct-current system. The system is fed from four substations each of which has direct-current conversion capacity capable of carrying the load in its vicinity. The substations are approximately 3,000 ft. apart and are connected by tie lines as shown in Fig. 4. As can be seen from this diagram, No. 2 substation is centrally located with respect to the other three substations. Normally the tie lines running from No. 3 and No. 5 substations to No. 2 substation are closed. No. 8 substation is tied into the system only in case of emergency.

A graphic ground detector is installed in each of these substations. These detectors are standard switchboard type graphic voltmeters having 300-volt scales. The meters have a chart speed of 2 in. per hour. The voltmeter elements are not polarized, consequently with the connection scheme used, the meter is able to indicate a ground on either side of the line. A graphic meter having a permanent magnet or D'Arsonval type of voltmeter could be used just as well, provided the scale is arranged with zero in the center instead of at one end. This latter type of meter would indicate *which side* of the line was grounded, that is, a deflection to the left would indicate a ground on one side of the line while a deflection to the right would indicate a ground on the other side of the line.

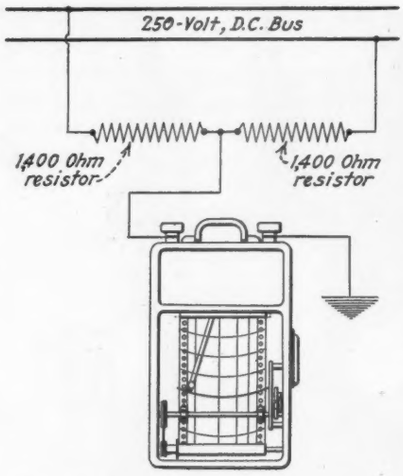
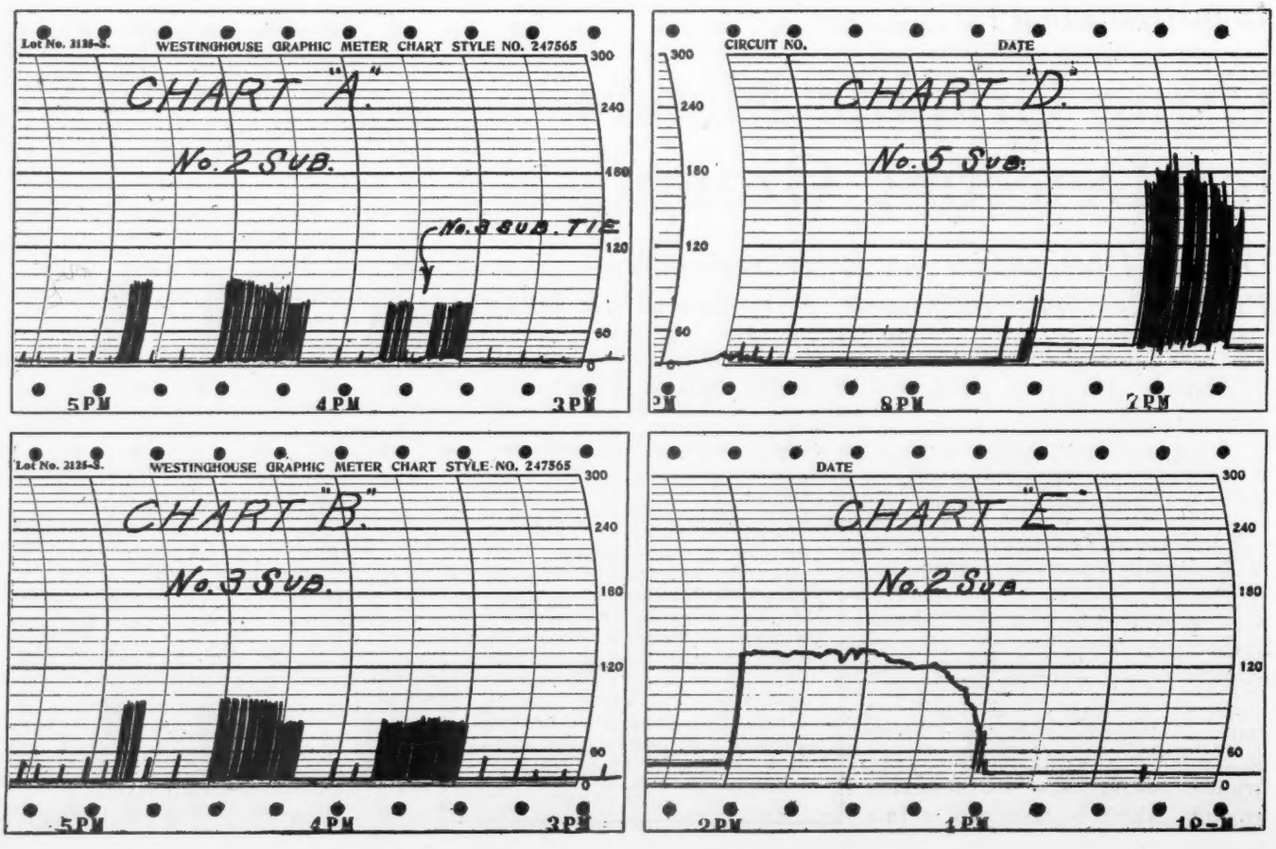



**Fig. 2—Connection scheme used for the graphic ground detector.** Two 1,400-ohm resistors are connected in series across the direct-current bus in the substations. The midpoint of the resistance is connected to one terminal of the graphic voltmeter, whose other terminal is connected to ground. This results in a Wheatstone bridge with the two resistors as two legs and the insulation resistances of each side of the line as the other two legs. The graphic voltmeter takes the place of the customary galvanometer.

In Fig. 2 is shown the scheme of connections for the ground detector meters. The graphic meters used were designed for use with an external resistor of 1,400 ohms, when used on a 250-volt circuit. Thus it was necessary, in order to obtain a measurement of the voltage from either line to ground, to use two 1,400-ohm resistors, one connected to each line as shown in Fig. 2. This results in the two resistors being connected in series across the line with the midpoint connected to the meter and the remaining meter terminal to ground.

With this arrangement we really have a Wheatstone bridge in which the voltmeter is the galvanometer, the two 1,400-ohm resistors are two legs of the bridge, while the insulation resistance between the positive side of the line and ground is balanced against the insulation resistance between the negative side of the line and ground to form the

**Fig. 3—These charts show how the character of the grounds was determined, thereby aiding in their location.** Chart *A* was taken in No. 2 substation and shows how the ground was cleared from this substation by opening the tie line breaker to No. 3 substation at 3:40 p. m. Chart *B* is the chart that was taken in No. 3 substation at the same time. The ground did not clear at 3:40 p. m. thereby indicating that it was on one of the feeders from this substation. Charts *D* and *E* show the difference between a reversing and a permanent ground.



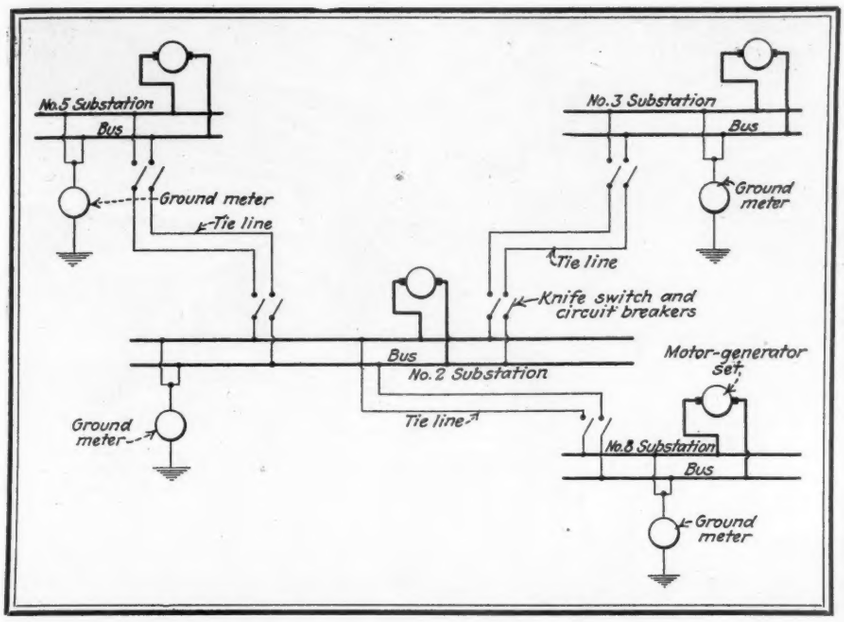



**Fig. 4—One graphic ground detector is placed in each substation.** As can be seen, there are four substations in this plant, which are tied together by tie lines. When indication of a ground is shown on the chart of one of the graphic ground detectors, the tie lines are opened so as to isolate the substation in which the meter is located. If the indication continues on the chart, the ground is on the section of the system which this substation serves. Interpretation of the character of the curve given by the graphic meter further aids in locating the ground.

other two legs of the bridge. As long as the insulation resistances between the two sides of the line and ground are approximately equal the voltmeter will give a zero indication. However as soon as an insulation failure or partial ground occurs the balance will be upset and the graphic voltmeter will give a deflection. Our experience has been that the meter will accurately show a ground as low as 20 or 30 volts, which in reality is a negligible ground.

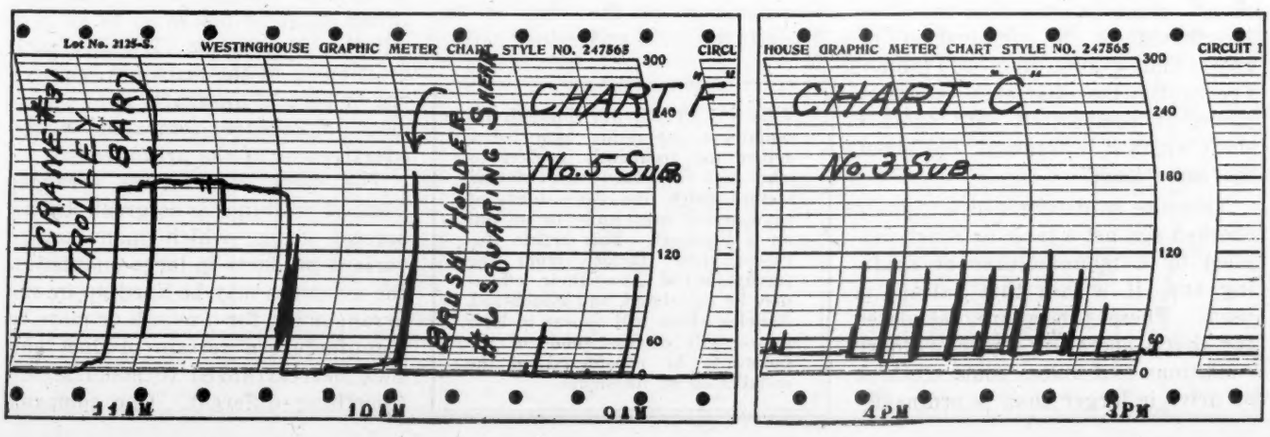
In case a graphic voltmeter not requiring an external resistor is to be used, two lamps may be connected in series across the line and the midpoint between the two lamps connected to the meter just as was done with the resistors.

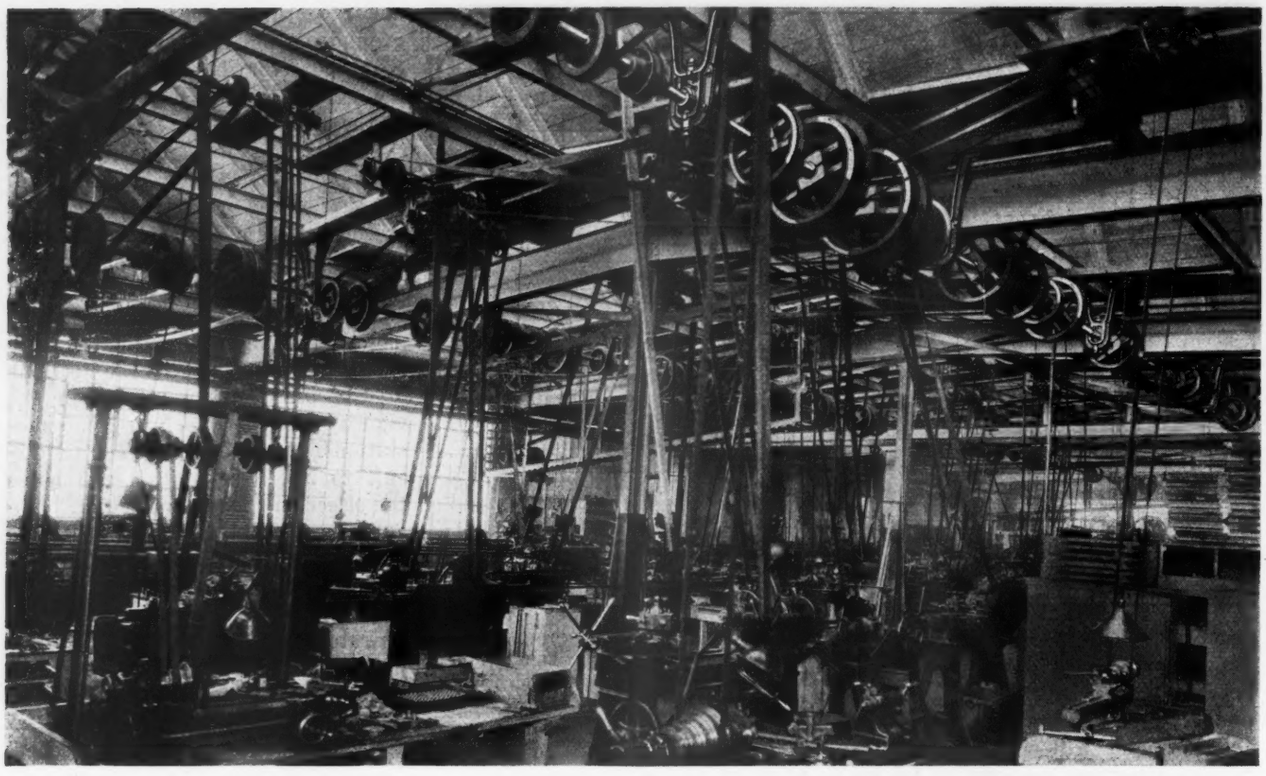
The ground meters are located on the front of one of the panels in each substation as shown in Fig. 1, where they are clearly visible to foremen and operators in passing. When an operator notices a deflection on the chart of his ground meter, he opens up the tie-line circuit breaker so as to isolate his section of the system from the rest of the distribution system. If the deflection on the meter continues, he knows that the ground is on one of the feeders going out from his substation or on the motors supplied by these feeders. If the meter goes to zero when the tie-line circuit breaker is opened, he then knows that the ground is not in his part of the system. Assume that the operator in No. 2 substation observes a deflection on his meter. He immediately opens the tie circuits to No. 3 and No. 5 substations. If the meter returns to zero, this at once localizes the ground to the sections of the distribution system in the vicinity of either No. 3 or No. 5 substations. He then closes the tie circuit to No. 3 substation and notes the effect on the ground meter. If a deflection is obtained, this shows that the ground is on the distribution from No. 3 substation. No. 2 substation operator then calls the operator in No. 3 substation and reports to him the results of his test which he can verify by the record on No. 3 substation graphic meter at the time the tie circuit was opened. The operator, in the substation at fault, then advises the foreman in that department of the ground on his equipment.

A study of the interval and duration of the lines on the graphic charts is of great help to the foreman in definitely locating the machine at fault. Chart *A* of Fig. 3 is taken from the graphic meter in No. 2 substation. At 3:30 p.m. a ground appeared. It was unnoticed for the first ten minutes after its appearance. At 3:40 p.m. the operator saw the record on the chart and started opening the tie line breakers. As soon as the tie-line breaker to No. 3 substation was opened the graphic indicated zero voltage, thereby showing that the ground was in that part of the system fed from No. 3 substation.

(*Please turn to page 459*)

**Fig. 5—The chart gives a record of the time at which the ground appears and the time elapsing before it is cleared.** This gives an incentive to clear the ground as quickly as possible because the record then shows that the maintenance man is on the job. In chart *F* a ground appeared, which was quickly found to be on the brush holder of a shear motor. Twenty-five minutes later another ground appeared which was not located for 40 min. It was found on a trolley collector rail of a crane. As soon as a ground has been cleared notations are made on the chart as shown to tell the location of the ground.





*Here two lineshafts which transmit power to a miscellaneous group of machines are belted together and driven by one motor.*

*Some of the Points To Consider When*

# Planning a Lineshaft Installation

## *With Factors Which Determine Size of Shaft Required and Affect Method of Grouping Machines on Shafts That Transmit Power to Them*

By FRANK E. GOODING
*Associate Editor, Industrial Engineer*

DIAMETER of a lineshaft for a group drive in industrial plants is altogether too often determined by a combination of guess and a few rules of thumb. Frequently the diameter is determined by comparison with another shaft which it is assumed "has about the same load."

This size so determined is usually checked against a table or chart supplied by a manufacturer of shafting and, if within that rating, is used. These tables are calculated for shafts operating under ordinary conditions and unless some machine or drive is larger than is ordinarily found in the average group drive, using such a size of shaft, the installation will probably operate satisfactorily.

Several points which affect the determination of the size of the lineshaft would, if understood better, be more appreciated and considered in both the estimation of the size and in the layout or arrangement of the installation. These points must necessarily be general in that lineshaft installations are seldom alike.

Practically all industrial plants are different in the layout and arrangement of the machines and in the size and shape of the buildings. Economical and efficient production determines the grouping and arrangement of the machines. This is much more important in plants working on a definite product or group of products because the routing of the material and semi-finished parts must then follow as nearly as possible a straight line. The machines must be placed so as to permit this if possible. Whether such positioning of the machines requires one or several lineshafts is of secondary importance, compared to the effectiveness of the arrangement.

The value of effective arrangement of machines is so great that in several shops, which manufacture various products in large quantities, the machines may be lined up in one arrangement for a month or more to manufacture a certain product and then be rearranged to manufacture something different. One company

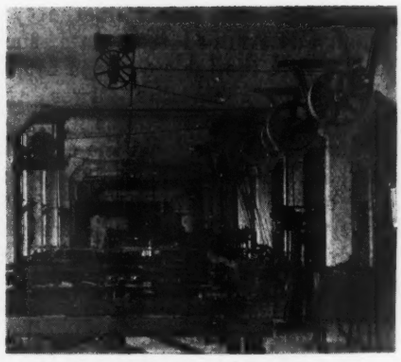
**WHEN LAYING out lineshaft installations, operating men altogether too frequently neglect to take into account some of the factors which may cause loads of unsuspected magnitude to be put on a lineshaft. This article discusses these factors from the standpoint of how their effects may be calculated, and minimized. Articles which will appear in later issues will discuss some of the points to be considered in the installation of lineshafts.**

even moves lineshafts and countershafts as may be necessary to improve the layout of the machinery on jobs which last only a month or two. Here the whole plant will work on one job until it is finished and then take up the next order, rearranging the machines and drives as necessary.

Ordinarily shops which do jobbing or a variety of work such as tool rooms, manufacturing plants that do jobbing on contract, and factories which turn out a variety of products, group machines of a type together. These groups of one type of machines generally make easier lineshaft layouts than when a variety of machines are arranged together, as is frequently the case.

### Advantages of Small Groups Over One Large Group

A number of advantages result from making several small groups of lineshaft drives instead of one large group, even though it is possible to use a single group and one lineshaft. In the first place, lineshafts of smaller diameter may be used, which will also take smaller hangers and bearings. This will decrease the cost of the shaft, bearings, and hangers. Shafting is sold by weight and a $3\frac{7}{16}$-in. shaft weighs twice as much per foot as a $2\frac{7}{16}$-in. shaft and three times as much as a $1\frac{15}{16}$-inch shaft. The cost of bearings and hangers increases with increase in shaft size in about the same proportion.



**The lineshaft speed is made to fit all machines but one.**

When determining the speed at which the lineshaft is to operate, an average speed, suitable for the different machines, is chosen. Usually, however, a few machines operate at speeds considerably above or below the average. In such cases it is generally best to ignore them in computations, so as to obtain the most suitable speed for the average machines. The few exceptional machines can then be driven through countershafts, as is the small grinder in this illustration, to better advantage than by using a speed poorly adapted to the majority of machines. Many lineshaft speeds are held down to accommodate the low operating speed of a power-driven hacksaw. It would be much more economical and effective to operate the lineshaft at a higher speed and install a countershaft, similar to the one used here on the grinder, to step down the speed for the hacksaw.

Under average conditions a $2\frac{7}{16}$ in. shaft will carry about twice the load of a $1\frac{15}{16}$-in. shaft. The $3\frac{7}{16}$-in. shaft will carry about five times as much as a $1\frac{15}{16}$-in. shaft and between two and three times as much as a $2\frac{7}{16}$-in. shaft. Thus an installation which requires a $3\frac{7}{16}$-in. shaft could be split up into four groups each of which would take a $1\frac{15}{16}$-in. shaft. If the load on the single shaft were 40 hp. each of the smaller shafts could be operated at about 10 hp. The four smaller shafts, hangers and their bearings would cost about a third more than for a single big shaft of the same length. The cost of erecting the four smaller shafts, however, would most likely be less than for the one large one because they could be handled more easily.

Four individual motors would cost a little over twice as much as a single large motor of the same rating. A single large lineshaft would probably require one or more auxiliary lineshafts, which would add to the cost. The four smaller groups would probably not require any additional auxiliary shafting, which would be an advantage.

Although the four groups would probably cost more for the complete lineshafts and motors than the single shaft layout there are other advantages in the smaller groups which would largely offset this. For instance, in case only a few machines were to be operated overtime only one or perhaps two groups might need to be operated. With a single

## Table for Determining Horsepower of Shafting Under Different Conditions

| Diameter of Shaft | For Head Shafts, Heavy Strains, shafts with gears, etc. H. P. = $\frac{D^3R}{125}$ | | | | | | | | For Line Shafts, with bearings every 8 ft. H. P. = $\frac{D^3R}{75}$ | | | | | | | | For simple transmission of power with no bending strains. H. P. = $\frac{D^3R}{50}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Revolutions per minute | | | | | | | | Revolutions per minute | | | | | | | | Revolutions per minute | | | | | | | |
| | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| $1\frac{3}{16}$ | 0.6 | 1.3 | 1.8 | 2.6 | 3.3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 6 | 7 | 9 | 11 | 2 | 3 | 5 | 7 | 8 | 10 | 13 | 17 |
| $1\frac{7}{16}$ | 1.2 | 2.3 | 4 | 5 | 6 | 7 | 9 | 12 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 3 | 6 | 9 | 12 | 15 | 18 | 24 | 30 |
| $1\frac{11}{16}$ | 2 | 4 | 6 | 8 | 10 | 11 | 15 | 19 | 3 | 6 | 10 | 13 | 16 | 19 | 26 | 32 | 5 | 10 | 14 | 19 | 24 | 29 | 38 | 48 |
| $1\frac{15}{16}$ | 3 | 6 | 9 | 12 | 15 | 17 | 23 | 29 | 5 | 10 | 15 | 19 | 24 | 29 | 39 | 48 | 7 | 15 | 22 | 29 | 36 | 44 | 58 | 73 |
| $2\frac{3}{16}$ | 4 | 8 | 13 | 17 | 21 | 25 | 33 | 42 | 7 | 14 | 21 | 28 | 35 | 42 | 56 | 70 | 10 | 21 | 31 | 42 | 52 | 63 | 84 | 105 |
| $2\frac{7}{16}$ | 6 | 12 | 17 | 23 | 29 | 34 | 46 | 58 | 10 | 19 | 29 | 39 | 48 | 58 | 77 | 97 | 14 | 29 | 43 | 58 | 72 | 87 | 116 | 145 |
| $2\frac{11}{16}$ | 8 | 15 | 23 | 31 | 39 | 46 | 62 | 78 | 13 | 26 | 39 | 52 | 65 | 78 | 104 | 129 | 19 | 39 | 58 | 78 | 97 | 117 | 155 | 194 |
| $2\frac{15}{16}$ | 10 | 20 | 30 | 40 | 50 | 61 | 81 | 100 | 17 | 34 | 51 | 68 | 85 | 101 | 135 | 169 | 25 | 51 | 76 | 101 | 127 | 152 | 203 | 254 |
| $3\frac{7}{16}$ | 16 | 32 | 49 | 65 | 81 | 97 | 130 | 162 | 27 | 54 | 81 | 108 | 135 | 163 | 217 | 271 | 41 | 81 | 122 | 163 | 203 | 244 | 325 | 406 |
| $3\frac{15}{16}$ | 24 | 49 | 73 | 98 | 122 | 146 | 195 | 244 | 41 | 81 | 122 | 163 | 204 | 244 | 326 | 407 | 61 | 122 | 183 | 244 | 305 | 366 | 488 | 610 |
| $4\frac{7}{16}$ | 35 | 70 | 105 | 140 | 175 | 210 | 280 | .... | 58 | 117 | 175 | 233 | 291 | 350 | 466 | .... | 87 | 175 | 262 | 350 | 437 | 524 | 699 | .... |
| $4\frac{15}{16}$ | 48 | 96 | 144 | 192 | 240 | 290 | 385 | .... | 80 | 161 | 241 | 321 | 401 | 481 | 642 | .... | 120 | 241 | 361 | 482 | 602 | 723 | 963 | .... |
| $5\frac{7}{16}$ | 66 | 133 | 200 | 265 | 332 | 400 | .... | .... | 111 | 222 | 333 | 444 | 555 | 666 | .... | .... | 166 | 333 | 499 | 666 | 832 | 998 | .... | .... |
| 6 | 86 | 173 | 260 | 345 | 432 | 520 | .... | .... | 144 | 288 | 432 | 576 | 720 | .... | .... | .... | 216 | 432 | 648 | 864 | 1080 | 1296 | .... | .... |
| $6\frac{1}{2}$ | 110 | 220 | 330 | 440 | 550 | .... | .... | .... | 183 | 366 | 549 | 732 | 915 | .... | .... | .... | 275 | 549 | 824 | 1099 | 1373 | .... | .... | .... |
| 7 | 137 | 275 | 412 | 550 | 686 | .... | .... | .... | 229 | 457 | 686 | 915 | 1143 | .... | .... | .... | 343 | 686 | 1029 | 1372 | 1715 | .... | .... | .... |
| $7\frac{1}{2}$ | 170 | 337 | 506 | 675 | .... | .... | .... | .... | 281 | 563 | 844 | 1125 | .... | .... | .... | .... | 422 | 844 | 1266 | 1688 | .... | .... | .... | .... |
| 8 | 205 | 410 | 614 | 820 | .... | .... | .... | .... | 341 | 683 | 1024 | 1365 | .... | .... | .... | .... | 512 | 1024 | 1536 | 2048 | .... | .... | .... | .... |

shaft for all machines the whole line is operated even if only one machine is to be used. Also, with the several smaller groups it is feasible to keep a spare motor which could replace quickly any one of the motor drives which might fail. Any such failure would interrupt the operations of only one group and so only part of the shop would be down in case a motor failed and no spare was available. When a number of machines are divided into several groups it is usually possible to get a better arrangement of the equipment and often a more effective utilization of the space. It is far better and more economical to put an installation in as it ought to be, even though the first cost is higher, than to make the best of a poorly planned layout which must always be operated uneconomically or changed later at an added expense.

The laying out of machinery in the most economical arrangement is a special task which space does not permit of extensive treatment here. Probably the best method to use is to make a drawing of the floor plan and then, on the same scale, draw and cut out templets of each machine to be installed. The problem then is a cut-and-try arrangement of these templets until they are placed in the best position for routing of work, aisle space, lighting, convenience and power drive. The result is usually a compromise on some of these points.

In determining the diameter of lineshaft for any particular installation the fact that every shaft is under a bending and twisting stress cannot be given too much importance. The bending stress is the more important of these and also is the more generally neglected. Although the size of a lineshaft is usually determined from data, such as given in the table on page 419, it is well to check the larger and heavier drives taken off the lineshaft to find their effect upon the shaft.

The bending stress is due to the pull of the belt, the weight of the pulley and its distance from the hangers. On any belt drive the effective belt pull is the difference in tension between the tight and the loose sides of the belt. For example, if this difference in tension is 100 lb. and the belt speed is 3,300 ft. per min., the belt is transmitting 10 hp. Under general conditions the tension of the belt on the tight side is about twice that on the slack side. Thus, in the example given above, the pull on the tight side of the belt would be 200 lb. and on the slack side 100 lb. which, with the addition of 100 lb., for the weight of the pulley, would make a total bending load of 400 lb. due to this single drive. Assume, for convenience, that this pulley is placed midway between the hangers, which are ordinarily spaced 8 ft. apart. The bending load is therefore [400 (lb.)÷2]×[96 (in.)÷2]=9,600 inch pounds.

Increasing the distance between the hangers, however, increases the bending moment proportionately even though the load is not changed. Thus, if the same load were placed midway between hangers 12 ft. apart the bending moment would be 14,800 in.-lb.

The corresponding twisting moment of this drive, assuming a 36-in.

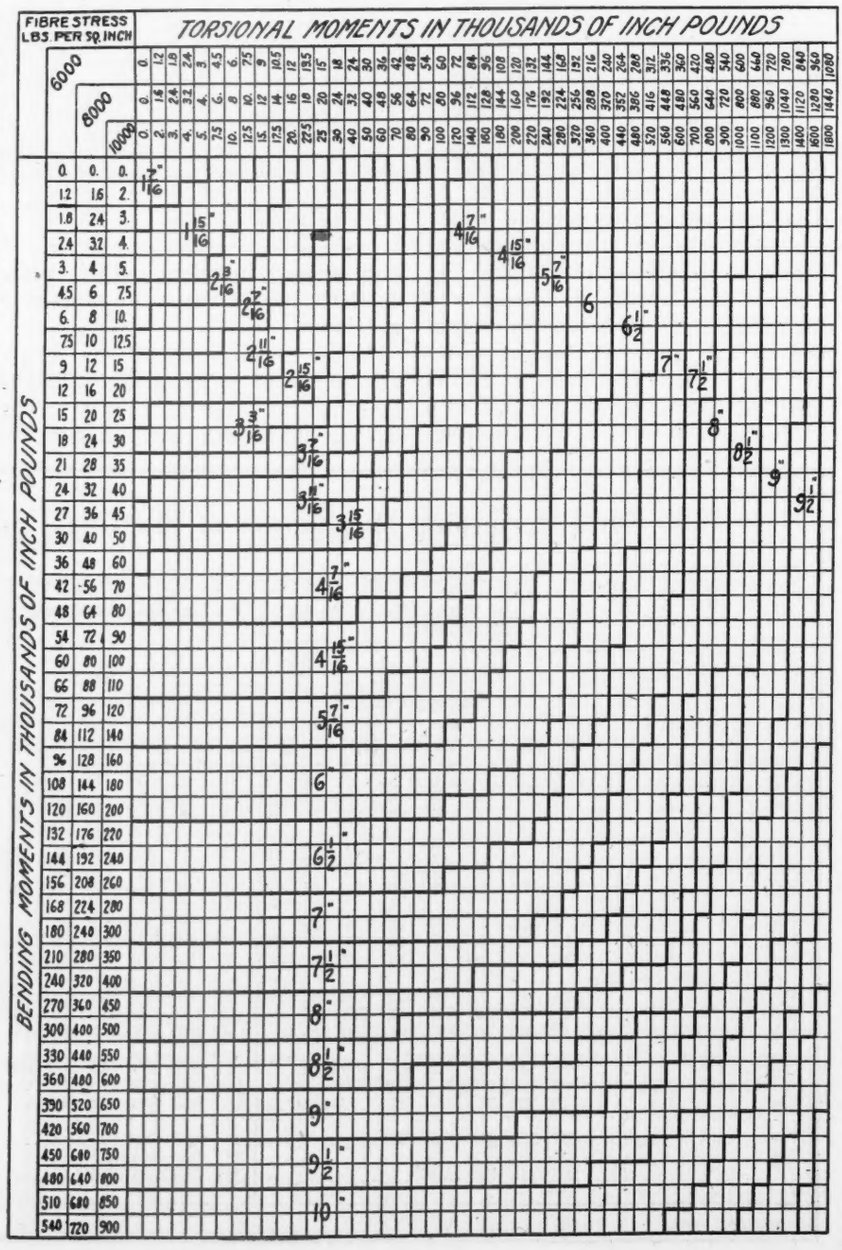
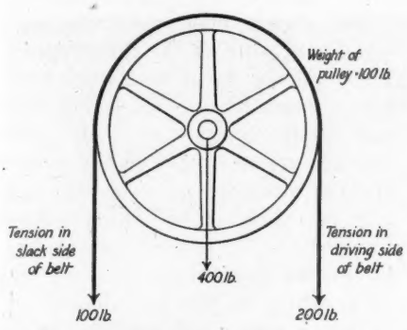



**Chart of combined torsional and bending moments for determining proper shaft sizes.**

After the bending and torsional moments have been computed, as explained in the text, the shaft size as determined by the table on page 419 is checked with this chart to see that the stresses do not exceed the permissible loads on that shaft size. The first step in this is to determine the permissible fiber stress in pounds per square inch, which is given in the upper left-hand corner of the chart. For light service the higher figure is used; for heavy service it is desirable to use the low figure. The figures at the top of the chart show the permissible torsional moments in thousands of inch-pounds for these fiber stresses; the column at the left shows the permissible bending moments in thousands of inch-pounds. In using the chart extend a vertical line down from the torsion load to the intersection of a horizontal line from the bending load. The intersection shows the size of shaft to use.




**This shows the direction and magnitude of the force which causes bending of a lineshaft.**

This bending force equals the tension in the tight side plus the tension in the slack side plus the weight of the pulley. The effect of this force on the lineshaft depends upon the distance of the pulley from the hanger, as is shown in the three sketches, *A*, *B* and *C* at the right. In the above sketch the ratio of tensions between the slack and tight sides of the pulley is one to two. With high-speed belts this ratio is sometimes increased to one to three.

pulley, would be 100 (lb. effective pull) × (36÷2) = 1,800 in.-lb.

Reference to the chart of "Combined Torsional and Bending Moments" on page 420 shows how these loads affect the shaft size. The detailed explanation of the use of this chart is given in the caption accompanying it and will not be repeated here. Assume that the desirable fiber stress should not exceed 8,000 lb. per sq. in. The results are that a $1\frac{7}{16}$-in shaft would take care of the torsion load if no bending load were present. However, the bending moment of 9,600 in.-lb., with hangers 8 ft. apart, would require a $2\frac{7}{16}$-in. shaft and the 14,800-in.-lb. bending moment resulting if the hangers are 12 ft. apart would require a $2\frac{15}{16}$-in. shaft.

If, however, this pulley were moved to a distance of 1 ft. away from the hanger on the 8-ft. spacing the bending moment would be 350×12=4,200 in.-lb. which is not too heavy a stress for a $1\frac{15}{16}$-in. shaft. The twisting or torsion load would not be affected by the position of the pulley relative to the hanger.

From this it is easily seen that the most attention must be given to the bending load and the effect of the position of this load with respect to the hangers. It is not the load alone but how it is applied that finally determines the size of a lineshaft, even though the rating is satisfactory as shown by a table similar to the one on page 419.

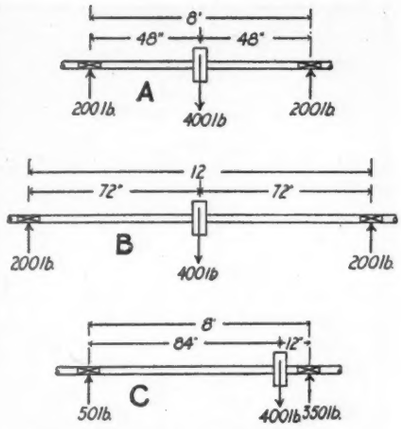
These facts bring out some of the most important points to consider. While 8-ft. spacing between hangers is good industrial practice it, should, nevertheless, not be such a fixed and set rule that the spacing can not be decreased or an additional hanger installed, where necessary, to place a hanger near a heavy bending load. If the shaft is already installed and a relatively heavy load for that shaft is moved so as to come midway between two hangers it is well to install another one nearer the load.

The arrangement of industrial machines is varied so frequently that it

## Power Required for Group of Machine Tools

| Machine | Horsepower |
|---|---|
| 1 band saw | 3 |
| 1 18-in. lathe | 4 |
| 2 10-in. lathes | 4 |
| 1 shaper | 3 |
| 1 power forge | 1 |
| 1 power hacksaw | ½ |
| 1 large drill press | 10 |
| 3 small pattern lathes | 3 |
| 2 small tapping machines | 2 |
| 1 small drill press | 2 |
| 1 milling machine | 3 |
| 4 small tool grinders | 12 |
| 1 small bench lathe | 1 |
| Total horsepower | 48½ |

NOTE: On this particular group drive a 10-hp. motor belted to the lineshaft was used. The motor horsepower in this case is 21 per cent of the total rated horsepower of each machine. In some cases where it is likely that many of the machines will be in operation all of the time the driving motor must be about 50 per cent of the total rated horsepower of the individual machines.

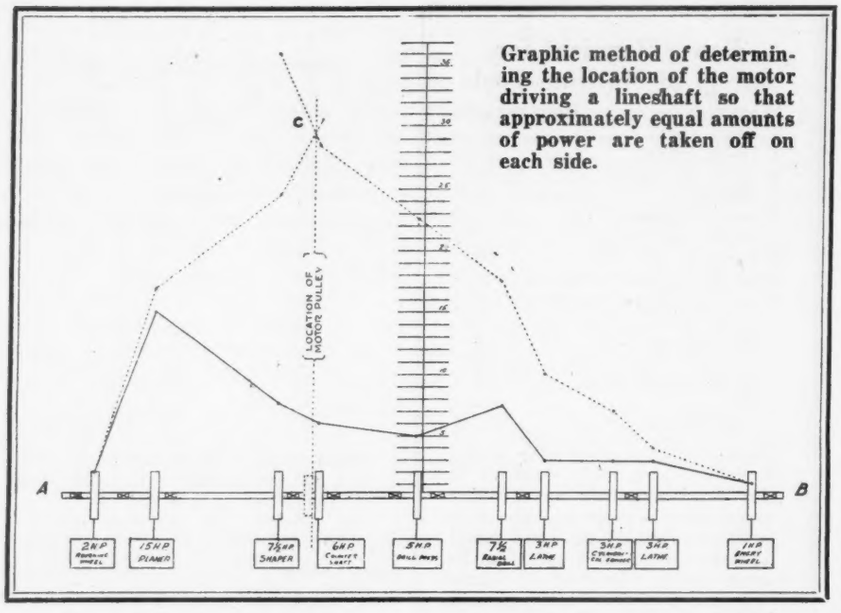



**Three typical examples of the effect of the application of the load on the bending moment.**

The effect of the bending moment upon the shaft is altogether too often neglected in determining sizes of shafts. These three sketches show typical examples of pulley locations and the effect of location upon the load. In *A* the pulley is placed midway between the two hangers, which gives it the highest bending moment possible on this type of installation. The bending moment is increased 50 per cent when the shaft hangers are placed 12 ft. apart, as in *B*. The resultant effect on shaft sizes is discussed in the text. Conversely, in *C* the bending moment is considerably decreased by placing the pulley close to the hanger. This is not only very desirable from the effect on the size of shaft required and its first cost, but also makes for more effective operation.

**A group of main and auxiliary lineshafts in a textile mill.**

Where long machines, such as these, are driven from lineshafts it is often necessary to group several pulleys between a pair of hangers. In such cases it is always advisable to place them as near the hanger as possible. How the bending moment on the lineshaft is affected by the distance the load is applied from the hanger is discussed in the text and in the captions accompanying the drawings at the top of the page.




**Graphic method of determining the location of the motor driving a lineshaft so that approximately equal amounts of power are taken off on each side.**

is seldom advisable to lay out lineshafts with the hangers spaced over 8 ft., even though at that time certain sections of the shaft do not drive any machines. In almost any shop additional machines are installed from time to time, which fact must be kept in mind when designing any lineshaft installation.

The permissible deflection of a lineshaft is 0.01 in. to the foot. If the hangers are spaced too far apart and a heavy load placed midway this deflection is often exceeded and is one of the most common reasons for pulley spokes breaking near the rim. This is due to the continual "weaving" of the face of the pulley as it is pulled straight by the belt while the pulley itself is tipped by the bending of the shaft. Breakage of pulleys where the spokes join the rim indicates that the lineshaft is too small, but can generally be remedied by adding a hanger close to the pulley.

Next to the loading of a lineshaft the speed at which it is to operate is of most importance. The tendency of the present-day installations is toward higher speeds. Much of this is due to the increasing use of ball, roller, and tapered-roller hanger bearings. Also, there is an advantage in using high-speed motors as these are cheaper and usually more efficient. If the lineshaft is speeded up, a smaller ratio of reduction is required between shaft and motor.

Because the power transmitted by any lineshaft is determined by the speed, any increase in the speed of the shaft will permit not only the use of smaller pulleys to obtain the same or higher belt speeds but also the use of a smaller size of lineshaft. Lower belt tension and generally narrower belts and pulleys may be used with higher speed operation, which lowers the first cost.

One power transmission engineer endeavors to make machine shop lineshaft installations operate at about 250 to 300 r.p.m. Former practice has been to operate shafts in this industry at 125 to 175 r.p.m. Because manufacturers of metal working machinery have almost standardized on this lower speed of lineshafts, many of the machines are provided with pulleys which would give a good reduction ratio when operating at the lower speeds. The tendency today is toward high-speed operation of these machines and so in many cases only small changes are necessary in the pulleys and the machines in order that they may be connected to a higher-speed lineshaft. This engineer stated that in several installations the only machine which he was not able to connect to a high-speed lineshaft was a power hacksaw. He felt, however, that the advantages of operating all of the other machines at an economical speed overcame the disadvantages in connecting the hacksaw, which required a contershaft reduction. The modern practice with woodworking installations is to drive the lineshaft at 400 to 600 r.p.m. Practically all woodworking machinery operates at a high speed.

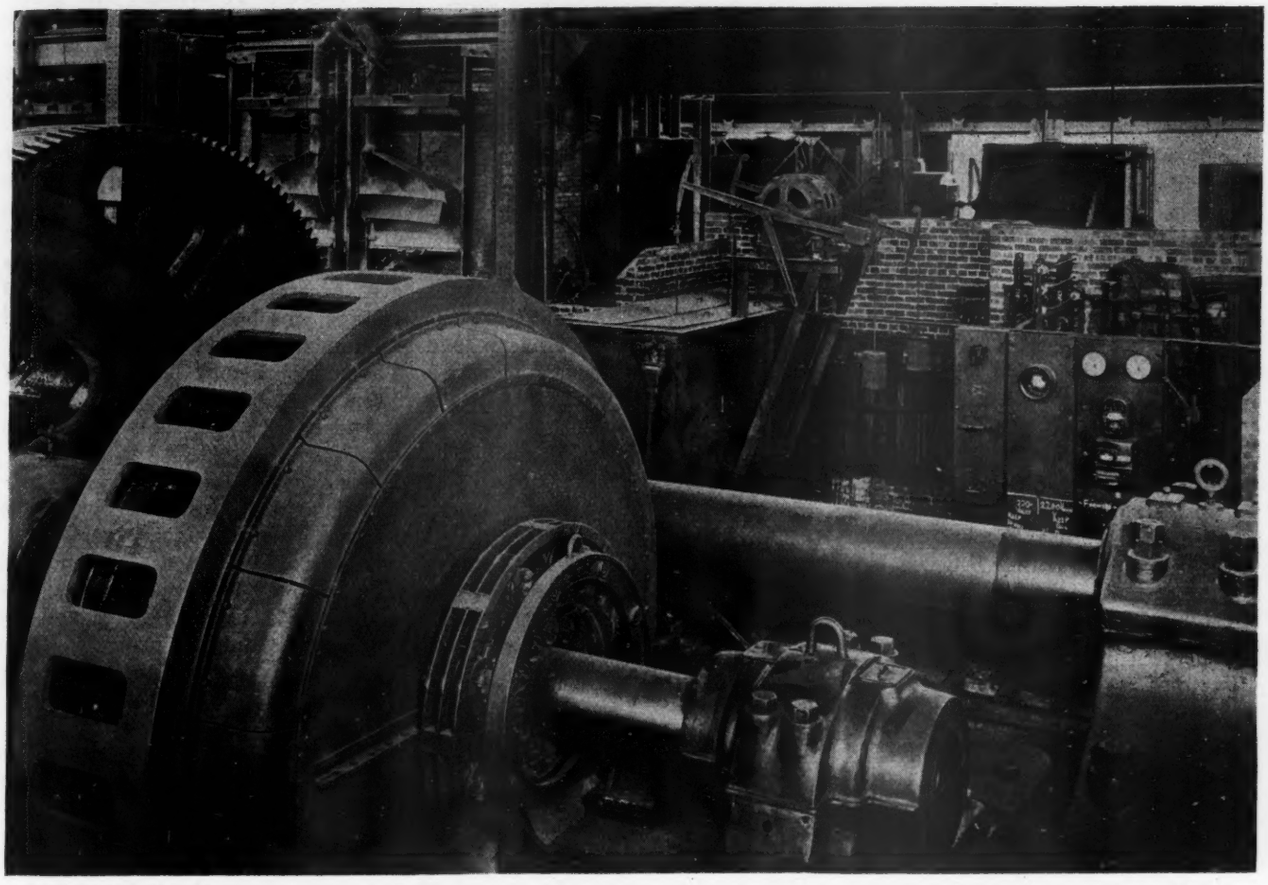
In determining the speed of a shaft, it is necessary to take what might be termed a good average operating speed for the entire group of machinery. The few exceptions which cannot be made to fit in with this speed can be taken care of to better advantage individually than by permitting the remainder of the machinery to run uneconomically so that special arrangements will not be necessary for the few exceptional machines.

An economical installation, taking into account the cost of pulleys and belts, operates at an approximate belt speed of 2,000 ft. per min., according to some curves and estimates made by R. C. Moore, Chief Engineer, Chas. A. Schieren Co. This belt-speed is somewhat low for

(*Please turn to page 460*)

**A typical arrangement of a group drive.**

In the arrangement of this group of machines particular attention was given to placing those which require the best lighting near the window. Note the criss-cross arrangement of lineshafts and countershafts.



*Good maintenance requires that the insulation be kept clean. When the motor is not located in a separate motor room, keeping the motor clean is sometimes quite a problem. In this hot sheet mill, enclosing covers were placed on the motor and air from an air washer is forced through a ventilating duct to the motor. The air washer and blower are shown on page 456.*

*Important Factors Regarding the*

# Maintenance of Large Motors in Steel Mills

## *Including Methods of Protecting Equipment From Dust, Dirt, and Sweating Together With Tests That Should Be Periodically Made on the Machines*

By O. NEEDHAM

*Steel Mill Section, General Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

**AN ANALYSIS of a sample of dust taken from the bedplate of a rolling mill motor showed that 81 per cent of the sample was composed of good conducting material, which would tend to introduce creepage currents that would break down the insulation of the motor. It is for this reason that greater precautions must be taken to protect electrical equipment in steel mills than in many other industries. In this article Mr. Needham describes some of the methods that may be used to prevent the accumulation of dust in the motor and sums up details of the maintenance required on large, steel mill motors.**

THE need of insuring proper maintenance — an important one with respect to any kind of machinery—is especially important with regard to electric equipment for large motors in steel mills.

All electric motors, reduced to their simplest form consist of copper for conducting the currents, iron for forming the magnetic path, and insulation for confining the electric current to the copper conductors. In addition to the above there must be mechanical parts for properly holding the working material together and for transmitting the power mechanically to the driven mechanism. This latter refers particularly to the spider, shaft and bearings.

Since all rotating electric machines, except squirrel cage induction motors, must receive or deliver some of their electric current through sliding contacts, which are commutators on direct-current machines and slip rings on induction and synchronous motors, these sliding contacts must also be regarded as a vital part of the machine.

A consideration of proper maintenance must, therefore, give attention to each of the divisions mentioned above.

Very little can happen to the copper and iron parts of a motor except from vibration, or excessive peak loads which might distort or crystallize the copper conductors. A number of things can affect the bearings,

such as vibration, dirt, improper lubrication and excessive pressures.

Commutators are affected by moisture and oil as well as vibration and dirt. Sparking may result from the above and also from roughness, high mica, improper brushes, and improper brush position. Numerous articles have been written covering causes and remedies for sparking and this will be passed over here with the comment that commutators must be kept free from moisture, oil, and dirt, and they must be stoned or ground when they become rough. The commutators should be checked occasionally to make sure that the holding bolts have not loosened.

Slip rings should be kept clean, true, and smooth and operated with proper and well-fitting brushes.

Insulation is the most vital part of the motor and unfortunately the most delicate. Insulation is affected by heat, dirt, oil and moisture, vibration, and abnormal voltages.

In reviewing the foregoing the one thing that affects the entire machine is mechanical vibration. This may cause crystallization and breakage of copper conductors, loosening of iron, damage to commutators, and pounding out of bearings. The vibration may be caused by improper alignment, loose foundation bolts, unbalanced rotor, unbalanced coupling, or may be transmitted to the motor from the mill equipment. It may also be caused by unbalanced electrical circuits. Careful attention must be given to all of these points at the time the installation is made and during subsequent periodic inspections.

Excessive bearing pressures may result from misalignment or from bent shafts. These points should receive attention from the inspector in his rounds. Bearings are also affected by vibrations which may develop a pumping action causing loss of lubrication. This also may damage the babbitt by pounding. Dirt getting into bearings is very disastrous as it will grind out the babbitt and cause heating. It also pollutes the oil rendering it unfit for use. The oil must be kept clean and changed or filtered as often as necessary. Under favorable conditions and ordinary care, once a year is ample. However, the oil should be inspected every month or at any time that there is reason to suspect that dirt has found its way into the bearings and must be changed or filtered upon any evidence of dirt or grit. The extremes of temperature at any locality may have considerable to do with the selection of the proper grade of oil to be used but a little study and observation will enable an operator to determine the best grade of oil for his conditions.

## Causes of Deterioration of Insulation

We next come to the important question of insulation. In accordance with the standardization rules of the American Institute of Electrical Engineers, steel mill motors are given an insulation test at the factory of twice normal voltage plus 1000 volts, insuring an ample factor of safety against insulation breakdown, but this wide margin of safety is naturally reduced after the machines are in service. The rate of deterioration depends on several causes, the principal among which are, excessive overloads, abnormal voltage, mechanical vibration, and accumulation of dirt and moisture. The moisture may be the result of sweating or of other causes. Let us consider each of these causes in turn.

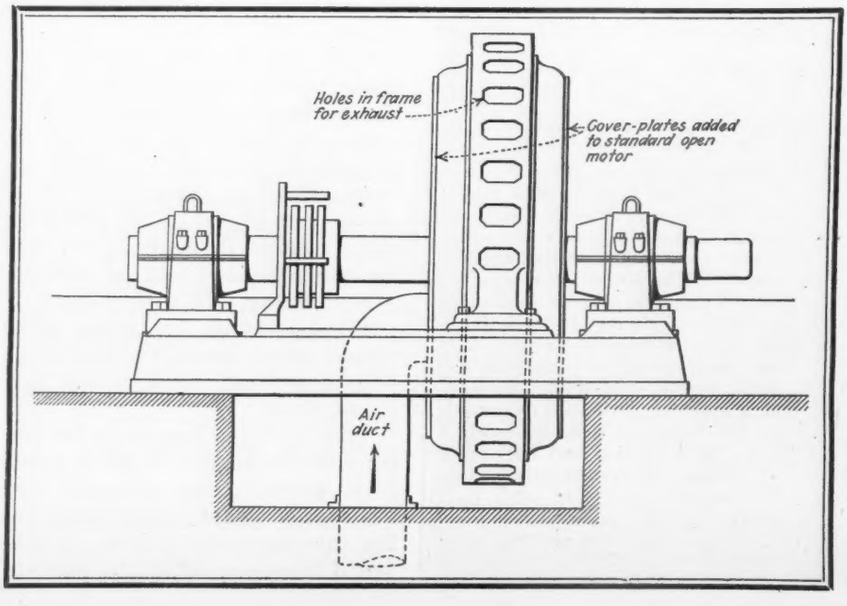
*Overloads*—Motors must be protected against injurious overloads by proper control apparatus.

*Abnormal Voltages* — Abnormal voltages may be occasioned by partial grounds, lightning, etc., and the insulation should be protected from break-downs due to this cause by suitable lightning arresters, reactors, and other standard devices.

*Vibration*—As stated before in this article mechanical vibration is caused either by improper alignment, loose foundation bolts, unbalanced couplings, or is transmitted to the motor from the mill equipment. Whenever possible the motor should be protected from vibration from the mill by the use of well-balanced flexible couplings.

**How a standard open type motor may be arranged for forced ventilation.**

Cover plates are added to the sides of the motor so as to tightly enclose it. Air is forced through a duct brought in at the bottom and at one side of the motor, goes through the motor, and exhausts into the room through the holes in the periphery of the frame. This method was used for the hot sheet mill motor shown on page 423.




## Dust Is the Most Common Source of Trouble in Windings

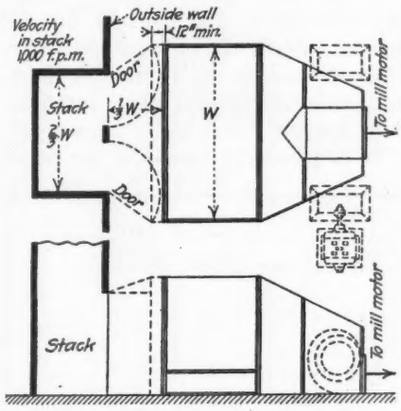
A very common source of trouble is the collection of dirt and dust in the windings. An analysis was made of a sample of dust taken from the bedplate of a rolling mill motor and the composition was found to be as given in the accompanying table. The carbon, iron oxide, and water compose 81 per cent of the sample and each of these components form good conducting material, which would tend to introduce creepage currents that would break down the insulation of the motor. It is for this reason that greater precaution must be taken in steel mills to protect electrical apparatus than in other industries where the atmosphere is not laden to such an extent with conducting material.

The best method of protecting a motor from this dust and dirt is to provide a motor house within the mill. When a motor house is provided it is easier to keep the apparatus clean and the mill men and unauthorized persons are kept away

from the electric equipment. One of the most important things to consider in the installation of a motor house is to make certain that the air for ventilating purposes is taken from a clean source. In every case the motor room should be completely closed off from the mill and where clean air is not directly available, an air duct with a blower should be provided. It frequently occurs that it is not possible to obtain clean air in a steel mill so that ventilating systems are usually provided with air cleaners. The amount of air necessary to ventilate a motor depends upon its electrical losses. It is best to have the manufacturer specify the amount of air necessary, but as a general rule about 10 cu. ft. per minute per rated horsepower will be sufficient. Gas fumes as well as dust and dirt should be kept out of the motor room.

In laying out ventilating ducts, care should be taken to avoid sharp turns as these seriously interfere with the passage of air. The ducts should be made as straight as possible and of such dimensions that excessive air velocities will not be encountered. Velocities in the duct of about 2,000 ft. per minute have been found very satisfactory for this purpose.

It is advisable to provide two intakes for air, one arranged to take air from the inside of the motor room, the other from the outside of the building. This arrangement is necessary since, in the winter the air which is taken from the outside may carry snow and ice into the windings. If an air washer is used it may become clogged with ice. With the arrangement mentioned above, all or a part of the air can be taken from inside the motor room in winter weather. It is best to proportion the amount of air taken from each source so that the temperature in the duct is not below 50 deg. F. A single door or shutter arrangement should be provided for the two intakes and arranged so that in closing one shutter the other is automatically opened. This will prevent the possibility of both intakes being closed at the same time, depriving the motor of its ventilation. This door will serve as a damper for properly proportioning the amount of air taken from each source, the door being fixed in the proper intermediate position. The diagram on this page shows a suggested arrangement.

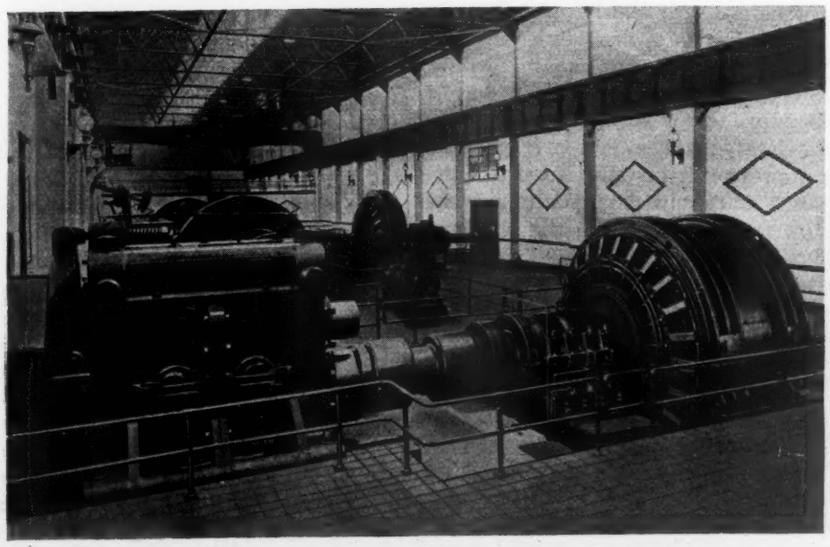



**Here is a good arrangement of blower and air washer in a motor room basement.**

Provision is made for taking air from outdoors through the stack as shown in lower diagram, which is an elevation view; or air may be taken through doors from the basement as shown in the top plan view.

When ventilating air is forced into the motor room the room should be designed with sufficient openings to provide free outlet for the air so that a pressure will not be set up in the room and the influx of air opposed, thus diminishing the amount of air given to the machines. A good plan is to install, near the roof, exhaust fans having sufficient capacity to expel approximately the same amount of air as is forced in by the blower. A slight pressure in the room is not objectionable as it prevents dust-laden air from coming in through doors and windows and other openings.

Sometimes it is not convenient to install a motor house. An instance of this kind is a hot-sheet mill. Some operators, in cases of this kind, have placed enclosing covers on the motors, provided a ventilating duct, and installed a blower and air washer for force-ventilating the motor with clean air. On page 423 is shown a motor so arranged with enclosing covers. The illustration on page 456 shows the blower and air washer. The duct is located under the collector rings. The diagram on page 424 shows how the duct is brought in.



**This is a splendid example of a motor room that was laid out with the view of securing proper care and maintenance of the equipment housed therein.**

Three large motors are located in this room, each of which drives main rolls located just outside of the room. The building is of brick and the walls and floor are of tile, thus dust does not readily enter and the room also is very easy to keep clean.

### How to Prevent Sweating of Motors and Generators

Sweating is a result of a difference of temperature between the machines and the surrounding air. If the air is saturated at a certain temperature, and is cooled below this point it gives up some of its moisture. When the temperature of the machine is low enough to reduce the temperature of the air below the dew point all excess moisture is precipitated upon the machine. This is very injurious to the insulation. This phenomenon is frequently noticed on cold water pipes when the humidity is high. If the room temperature is kept uniform at all times or if the machines are kept slightly warmer than the surrounding air, sweating will be prevented. When the machines are installed, arrangement should be made to keep them slightly warm at all times. During periods of more or less extended shutdowns the machines should be covered by tarpaulins and

a small amount of external heat applied to keep the machines at a temperature that will prevent sweating. Where high-voltage, alternating-current machines are installed in localities having high humidity, schemes have been worked up whereby 220-volt alternating current can be applied to the motor windings by simply switching the motor from its power line to the 220-volt shop circuit. This can be done very quickly and only a small amount of power is required. As the heat is applied internally, it is necessary to keep the temperature only a few degrees above that of the surrounding atmosphere to prevent precipitation. Some operators have arranged space heaters in the frames of large induction motors and others have arranged electric heaters made up from grids or have even used steam pipes under the motors to keep them warm during shutdown periods.

### Recommended Methods of Cleaning and Painting Machines

After the machines are placed in regular service the entire equipment should be kept clean, particularly the insulation. It is advisable to keep all machines painted as the paint will not only be a benefit to the machines by preventing rust and making them easier to clean, but also will be an incentive to the operators and attendants to keep the motor room and apparatus neat and clean. In addition to painting the iron and steel parts of the machines, the exposed parts of the windings, and particularly the creepage surfaces over the insulation, should be gone over at least once a year with a good insulating varnish. Most of the air drying varnishes will dry in from 24 to 48 hours with a room temperature of approximately 25 degrees C. If a shorter time is necessary the varnish can be dried more quickly by covering the machines with a tarpaulin, leaving an opening at the top for moisture to escape and placing resistance grid heaters under the machines to raise the temperature to not more than 100 deg. C. This treatment will cause the insulation to become smooth and glossy so that dirt will not adhere readily. A baking varnish is to be recommended in preference to an air drying varnish if conditions are such that it can be applied. This requires a somewhat greater preparation as the machine should be covered over and heaters provided to keep the machine at about 100 deg. C. for 24 hours. Previous to applying any kind of varnish the insulation must be absolutely clean. The machine may first be thoroughly blown out with a moderate pressure air blast and then wiped thoroughly with rags saturated in alcohol to make certain that all oil and dirt are removed. These rags should be drawn through between the coils and all pockets should be thoroughly wiped out.

### Analysis of Dust Found on Steel Mill Motor

| Component Parts | Per Cent of Sample |
|---|---|
| Water | 2.2 |
| Carbon as coke dust, etc. | 16.2 |
| Silica as slag, sand, etc. | 9.8 |
| Iron oxide as scale and ore | 63.0 |
| Aluminum oxide | 6.8 |
| Calcium oxide | 1.0 |

Of this sample, 81 per cent is good conducting material, which would tend to introduce creepage currents that would break down the insulation and cause a shutdown. It is for this reason that greater precautions must be taken in the maintenance of electrical equipment in steel mills than in other industries where the atmosphere is not laden to such an extent with conducting material.

### Insulation Resistance Should Be Measured Periodically

Periodic inspection should be given to the entire equipment, say every week or so, at which time the machine should be thoroughly blown out with a moderate pressure air blast—about 25 to 30 lbs. per sq. in. is the most satisfactory. As the mill line is usually high pressure—on the order of 100 lb. per sq. in.—it is advisable to provide a reducing valve and water trap so as to obviate any danger to the insulation due to moisture or a high-pressure blast. In some cases a low pressure air compressor is installed for this purpose. Care must be taken to prevent dirt from getting into the bearings during this cleaning.

At occasional inspection periods, the insulation resistance should be measured while the machines are still warm, and a permanent record kept. This will show whether any deterioration of insulation is taking place, and preventive steps can be taken before an actual breakdown occurs.

The insulation resistance can be taken with a high-voltage megger or a 500-volt d.c. circuit and a high-resistance voltmeter. A megger or megohmer is the more convenient method of measuring insulation resistance. If a grounded direct-current, 500-volt circuit is used, care should be taken to see that the grounded side is connected to the frame of the machine. In using a megger or megohmer the instructions coming with the instrument should be carefully followed, or misleading and erratic results may be obtained. These readings should be taken when the insulation is warm and the insulation temperature recorded with the reading.

When using a high-resistance voltmeter and a 500-volt, d. c. circuit, one side of the circuit is connected to the frame of the machine and the other to the bare windings through the voltmeter. The insulation resistance may then be determined from the following equation:

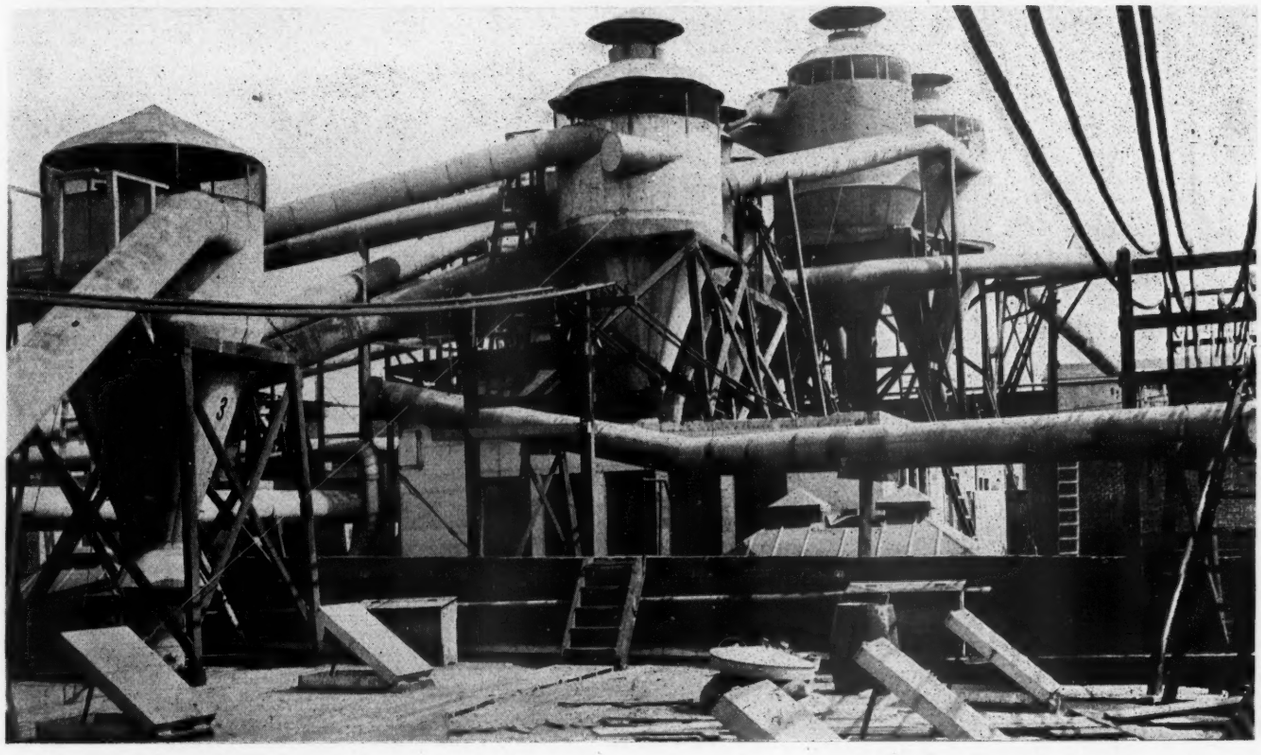
$$R = [(V - v) \times r] \div V$$

where R = the insulation resistance
r = the resistance of the voltmeter
V = the line voltage
v = the voltmeter reading.

The most positive method of measuring the ability of the insulation to withstand operating voltage is to apply actual potential tests on the insulation. This requires a small transformer testing box designed to give a wide range of voltages and having a capacity of about 1 kva. for each 1,000 volts rating of the high-tension side of the testing transformer.

The test voltage can be applied for a period of one minute and if a weak point is found, very little damage will be done, due to the small capacity of the transformer. On the other hand, if the apparatus is continued in service without discovering this weak point, the apparatus itself may be connected to a power circuit having considerable capacity and when the breakdown occurs, the large amount of power available may seriously damage the machine. Such a breakdown naturally occurs when the mill is in operation, and its delay is serious. If a testing transformer is used this can be done before the equipment is started up and the repair made before the mill is placed in operation. Before this voltage test is made, the machine should be blown out and all brass and copper parts wiped clean as the

(*Please turn to page 456*)



*This collection system is part of the pneumatic conveying installation which handles hemp, flax and other materials at the Brooklyn plant of the American Manufacturing Co.*

*Some Things It Pays To Know About*

# Handling Materials by Air in Industry

## *Such as the Equipment and Quantity of Air Required, the Different Materials Which May Be Handled in This Way and Some of the Advantages and Economies Resulting*

By CHARLES L. HUBBARD
*Mechanical Engineer, Boston, Mass.*

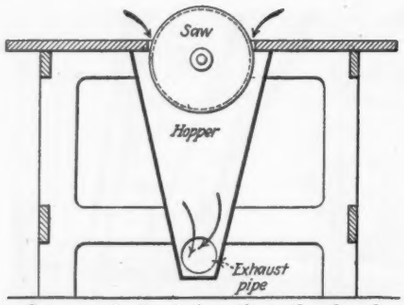
PREVIOUS articles in this series, which have appeared in earlier issues of INDUSTRIAL ENGINEER, have taken up the removal of fumes, vapors and fine dust by means of pneumatic systems employing a fan for producing the necessary suction. In each instance the material removed is light and will remain more or less suspended in air in motion. This article will discuss the means employed for handling coarser waste material such as sawdust and shavings, powdered coal, wool, cotton, ashes and numerous other light materials.

Dust and coarser waste are often produced in the same process, as in woodworking shops and similar industries, and if the coarser wastes are not too large or heavy are handled together. In some cases it is necessary to separate them, especially at saw mills and when dressing lumber where the sawdust and shavings are removed pneumatically and the coarser trimmings by some form of flight or belt conveyor.

**PNEUMATIC HANDLING of materials is taken up in this, the fourth and last article of a series on the use of exhaust systems in industrial plants. Previous articles have discussed the removal of fumes and gases, and the collection and separation of dust. This article covers the handling of heavier materials such as shavings, wool, jute bagging, and materials in pulverized or semi-pulverized form.**

The articles relating to the removal of fumes and dust have been closely connected with the ventilation problem and the health of the operatives. However, the handling of coarser materials relates more to the routine of manufacture, and may be applied equally well to conveying many types of raw materials into and sometimes through the process of manufacture, as well as disposing of the waste. This feature of pneumatic conveying will also be touched upon in the present article.

In general the handling of coarse material in woodworking shops, shoe factories, and so on, is accomplished in much the same way as the handling of the finer dust, except that special fans must be employed which are able to withstand blows from knots and splinters thrown from planing mills; and also to avoid clogging, as would be the case in handling long shavings from excelsior and shingle mills, wool, cotton and other fibrous products. Fans

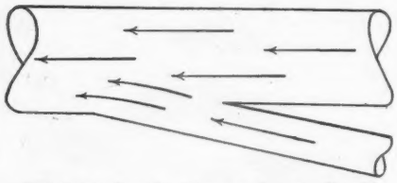



**One method of locating the hood or hopper of an exhaust pipe for a circular saw.**

are designed with particular reference to the material they are to handle. This should always be taken into consideration, when laying out an exhaust or pneumatic conveying system.

Shavings, sawdust, and so on, are removed through special hoods surrounding the cutting tools similar to those already described for collecting fine dust and fumes. An exhaust system for a woodworking shop differs from the pneumatic sweeper in the arrangement of its various parts, in that the separator, or collector as it is called, is generally placed on the discharge side of the fan instead of on the inlet side. For some pneumatic conveying, however, the separator is placed ahead of the exhaust fan.

The equipment used in the handling of waste in woodworking shops, with suitable modifications, is typical of that employed in other industries. Various woodworking machines require special forms of hoods according to their construction and the kind of work done by them. Drawings or prints showing the construction of the hoods are usually furnished by the makers of the machines. The construction of several types of hoods is shown in accompanying illustrations and the special features of each are described in the caption.

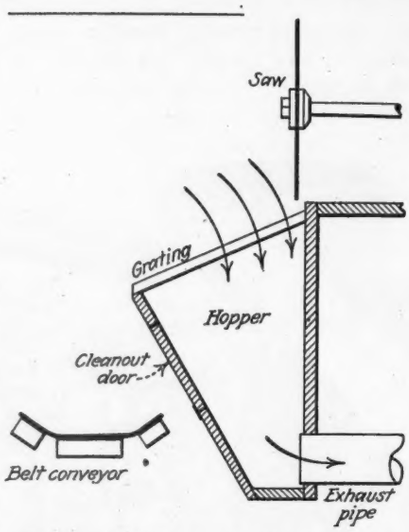


**Inlets to hood exhaust ducts should be gradual to give a stream-line effect.**

In general all hoods should be designed so as to provide the "streamline" effect and avoid eddy currents as much as possible. This calls for an easy flare at the entrance, and a gradual taper to the exhaust outlet. Also, particular attention should be given to the design so that the action of the cutter or saw will discharge the refuse into the hood in the direction of the flow of air and so assist the exhaust rather than retard its velocity.

The starting point in planning a system of this kind is at the machines and in the absence of more definite information from the manufacturer of a particular machine the dimensions for the pipe connections given on page 429 may be employed. In laying out a simple system of piping, as for the exhaust installation shown on page 430 it is well to make the main as straight and short as possible, and to cap the dead end so that it may be easily opened for inspection. Joints in the pipe should be lapped to offer no resistance to the flow of air nor edge to catch materials. The system should include as few elbows as possible, with the least radius not less than 1½ times the diameter of the pipe at that point.

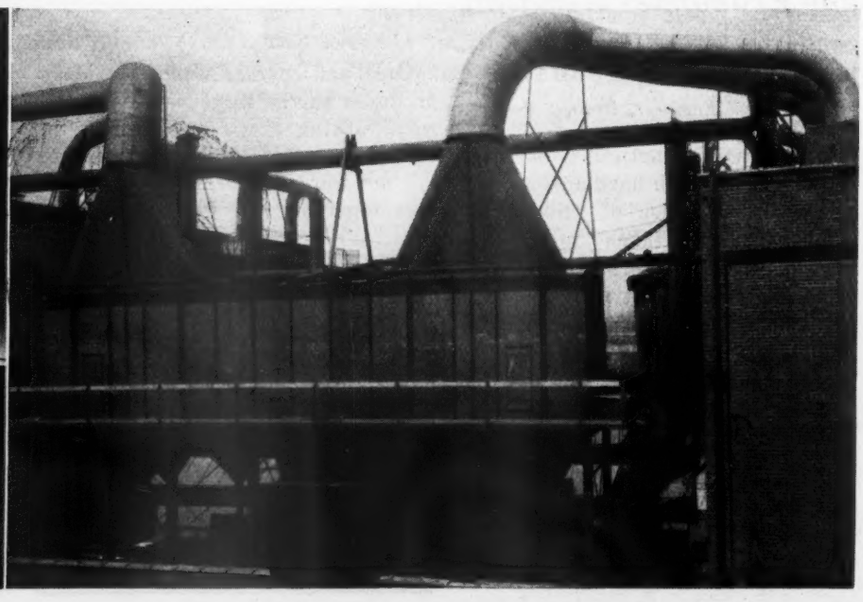
In addition to capping the dead end, as noted above, clean-out openings are provided at frequent intervals for removing obstructions, should they occur. When short vertical runs are necessary the area of




**The sawdust is drawn through the grating in the hopper, which serves as a hood, and sawed-off ends or edges fall onto a conveyor.**

**Two views of the conveying and collecting systems at the Armstrong Cork Co.**

The illustration at the left shows a complicated arrangement of pipes which enable the material to be distributed or collected from various locations. The illustration at the right shows one of nine large Sly dust arresters for collecting cork dust.



the riser may be restricted somewhat, thus increasing the air velocity through this section and so adding to the lifting power. If the vertical pipes are comparatively long, they are kept the same diameter as the horizontal runs and the necessary lifting power secured by increasing the velocity throughout the entire system. The method of proportioning the pipe and fan sizes for an installation is explained in connection with the illustration of an exhaust system on page 430 and the table on page 431.

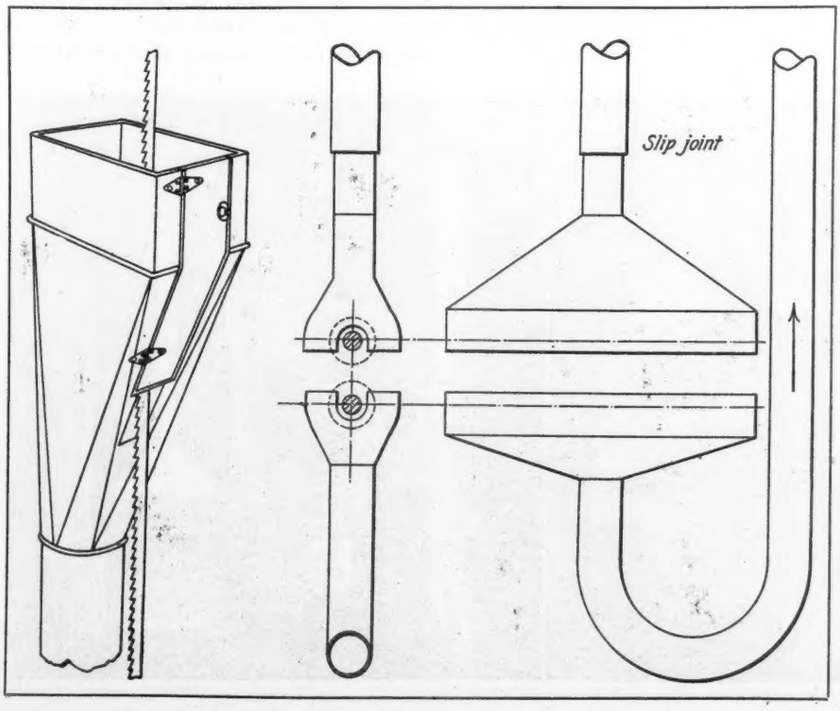
Blast gates should be placed in all exhaust connections and kept closed when the machines to which they lead are not in use, as this reduces the volume of air handled and prevents useless power consumption. This must not be done to such an extent, however, as to reduce the quantity of air passing through the main to a point where it falls below that necessary to carry the waste from machines still in use.

The air velocity through the exhaust ducts, which determines the suction, depends upon the kind of material to be handled, and usually runs about as follows: light shavings and sawdust, 2,500 to 3,500 ft. per min.; chips, bark, and so on, 3,000 to 5,000 ft. per min.; dust from leather and napping machines, 2,000 to 2,500 ft. per min.

Although the fans used in different exhaust systems are more or less of the same general type, modifications are frequently necessary to fit them for the special conditions under which they are to operate. For example, an ordinary mill waste, such as sawdust, planer chips, and so on, is handled by what is known as a standard mill exhauster, while long shavings from an excelsior mill require a special form of blade without projections on which the shavings may catch.

## Recommended Diameter of Hood Connections

| Type of Machine | Inches |
|---|---|
| Matcher heads, each | 5 |
| Sash and cabinet shaper, each head | 4 |
| Door tenoner | 5 |
| Sash tenoner | 4 |
| Door and sash sticker, each head | 4 |
| Blind slat sticker | 4 |
| Blind rail router | 4 |
| Panel raiser, each head | 4 |
| Sand drum 29 in. long | 4 |
| Sand drum 30 in. long | 5 |
| Sand drum 36 in. long | 6 |
| Sand drum 48 in. long | 9 |
| Sand drum 60 in. long | 11 |
| Belt sander up to 4 in. wide | 4½ |
| Belt sander 4 in. to 8 in. wide | 5 |
| Belt sander 8 to 12 in. | 6 |
| Disc sander up to 24 in. dia. | 5 |
| Disc sander 24 in. to 36 in. | 6 |
| Rip saws and resaws up to 14 in. dia. | 4 |
| Rip saws and resaws 14 in. to 18 in. | 4½ |
| Rip saws and resaws 18 in. to 24 in. dia. | 5 |
| Cutoff saws not over 16 in. dia. | 4 |
| Band saws up to 1½ in. wide | 4 |
| Band saws 1½ in. to 3 in. wide | 4½ |
| Band saws 3 in. to 4 in. wide | 5 |
| Band saws 4 in. to 6 in. wide | 6 |
| Buzz planers, molders, planers and all other machines having knives of dimensions given: | |
| Up to 6 in. long | 4 |
| 6 to 8 in. long | 4½ |
| 8 to 12 in. long | 5 |
| 12 to 18 in. long | 6 |
| 18 to 24 in. long | 7 |
| 24 to 30 in. long | 8 |
| Floor sweep-up | 6 |




**Two types of hoods used on special machines.**

The hood at the left is made of sheet iron and fits under a bandsaw table to carry away sawdust. The illustration at the right shows a double hood to be used in connection with a planer. The upper hood telescopes in a slip joint for adjustments and repairs.

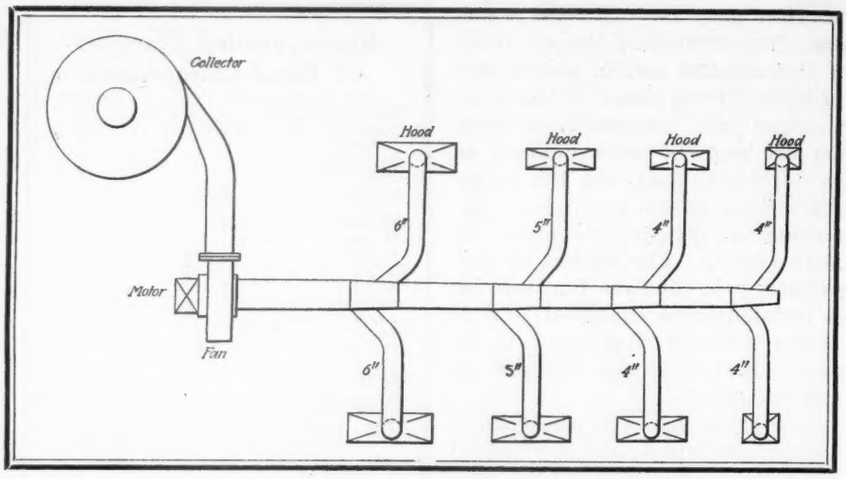
Fans for handling other materials, such as cotton, wool, strips of paper, jute bagging, excelsior, and so on, require still different construction. Steel plate casings are commonly used for the large sizes and cast-iron for the smaller. Where head room is limited and the main exhaust pipes come from opposite directions, it is often better to use two fans, which may be driven by one motor, as this eliminates elbows and the pipes run directly into the fan inlets.

Accurate methods for determining the size, speed and power of the fan should be used in laying out large and important systems. Computations of this kind, however, are best left to the engineers making a specialty of such equipment. Estimates for preliminary work, and for small layouts and extensions, can be made from tables and simple data found in the catalogs of most fan manufacturers. The table on page 431 gives some of this data. A simple example showing how to use it is given in the caption accompanying the table.

It will usually be found from a complete table of this kind that the work required comes within the range of two or three different sizes of fans, and that a selection may be made between smaller sizes operating at a higher speed or a larger fan operating at a lower speed. The latter often results in a lower operating cost and less vibration, although the first expense of installation is somewhat greater.

It should be remembered that the output of the fan which is dependent upon the velocity of the air, increases as the speed (r.p.m.) but the pressure increases in proportion to the square of the speed and the power required increases in proportion to its cube. It is well to consider this feature if it is at all likely that at some future time it will be desired to add machines to a line. A slight additional capacity in the fan will provide for this. To obtain increased capacity by operating a fan above its rated capacity and speed is possible only at the expense of a heavy increase in the power required to operate the equipment.

Exhaust fans are belted to the line




**A diagrammatic sketch of a typical woodworking installation.**

Here chips or shavings are drawn away from each machine through its hood into a main duct which discharges directly into the exhaust fan and are then blown into the cyclone collector. Some of the computations used in determining the size of fan for this installation are discussed in the explanatory matter in connection with the table on the opposite page.

shaft or to individual electric motors and, under certain conditions, are driven by direct-connected motors or engines. The best method of driving in any particular case depends on local conditions, and any of these mentioned should give good results wherever it is well adapted. The direct-connected unit is very satisfactory where the required speed of fan is not so great, as to require the use of special a.c. motors or other equipment.

When handling shavings and similar waste material the exhauster discharges into a collector which is commonly known as a cyclone separator. This is merely a circular chamber which serves to separate the air and the finer dust from the coarser material and thus prevent the strong drafts of air and clouds of dust which would result if it were not used. This device is simply a chamber of conical form in which the fan discharges tangentially near the top. As the mixture of air and fine and coarse material enters the chamber the pressure drops, which destroys the air velocity, and separates the fine dust from the coarser waste. The latter falls to the bottom of the cone, and from here passes through an opening to the fire room or furnace, while the fine dust passes out of the collector at the top with the air. The size and proportions of the collector vary somewhat with different makes and with the character of the material to be handled. In general, the inlet is made the same size as the discharge from the exhauster, or slightly larger, and the air outlet of such size that the low air velocity thus produced will carry but a small amount of dust with it.

The exhauster should be placed nearest the heaviest work, but yet conveniently central with regard to all of the machines. If, however, there are a large number of hoods to be taken care of, so that an extremely large unit would be required, some form of relay system is commonly employed. In this case the machines are conveniently grouped and each section is provided with its own fan collector. The refuse from the several collectors may then be carried to a final collector by means of a special exhauster, or the refuse from the first collector may be discharged into the inlet of the second fan, and so on, until the refuse is all relayed to the final collector which discharges into the fire room. In planing mills it is often possible by this means to reduce by one-half the diameter of the long discharge duct leading to the main collector.

Exhaust piping is commonly carried overhead, although in some cases it may be more convenient to

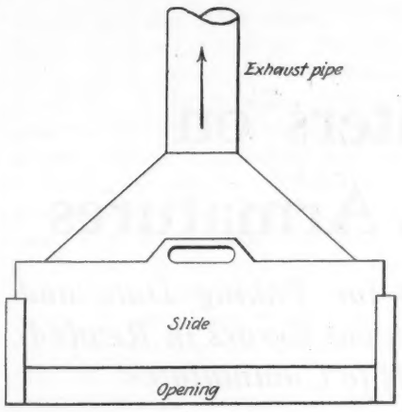
**Installation for handling shavings in woodworking plants.**

The illustration at the right shows the exhaust connections and hoods around woodworking machinery. The hood on the planer telescopes for adjustment or for repairs to the planer. The floor sweep-up at the left of the planer, which may be cut off by a blast cap, facilitates the rapid removal of sweepings. The illustration at the left shows the exhaust system in the woodworking department of a large automobile concern. Here the exhaust ducts are arranged on the ceiling of the floor below the machines with individual outlets extending through the ceiling.

run it on the ceiling below which, however, necessitates cutting through the floor for each machine While this might not be objectionable for permanent installations, it has its disadvantages where the layout may be shifted frequently.

The systems described for woodworking shops are typical of those employed in other establishments where refuse of a similar nature must be handled, as in shoe factories, grinding and polishing processes, and so on. Differences in equipment are principally confined to minor details of construction and operation, such as type and speed of fan, air velocity in ducts, size and form of collector, and so on.

Any material which is light enough so that it can be made to remain suspended in air for a time, may be carried along on an air current of sufficient volume and velocity. This has led to many large installations of pneumatic conveyors. The materials so handled may be divided in general into two classes: Those which are either finely pulverized or would become pulverized and give off a dust when handled, and those which would need to be baled or bundled to be handled economically.




**A type of floor sweep-up in which the slide at the opening serves as a blast gate.**

Some of the materials of this first class which are handled economically by air are: both granulated and pulverized cork, fertilizers, lithopone (both in powdered and lump form), arsenic as a byproduct of smelting ore, either rock or pulverized phosphate, bauxite, soda ash, white clay, powdered coal, and many other similar materials and products. Many of these materials mentioned would create a very objectionable and in some cases poisonous dust if handled by a man with a shovel, or by a grab bucket, or by any of the other common means of handling and conveying raw material; in some cases it would be almost impossible for a man to work under the conditions created. Air conveying creates practically no dust, as will be explained later.

Materials of the second class which would have to be bundled to be handled economically are: cotton, wool, jute bagging, hair, flax, hemp, shoddy, waste paper, tan bark, wood or paper pulp, grains and feeds, coffee and many other products. Although some of these are shipped and handled in bags, bales or bundles, it is often uneconomical to rehandle them loose by the common means of conveying particularly such materials as cotton, rags, waste paper, and so on, when moving between machines or processes or in or out of storage. It would be very expensive to bundle each time and this would not always be desirable after such operations as picking or cleaning cotton or wool.

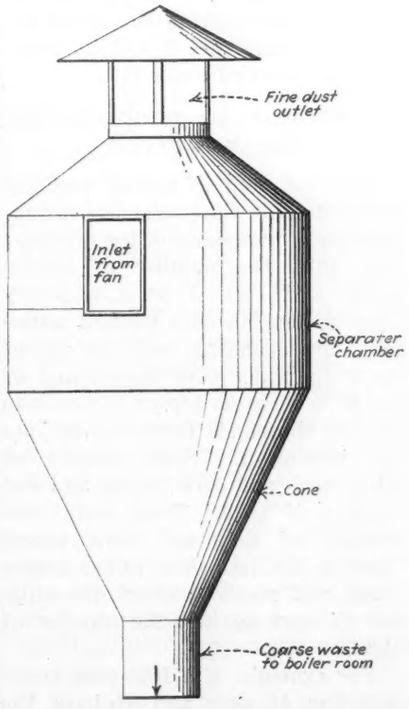
Pneumatic conveying generally is done in one of three ways. The most common type of pneumatic conveyor consists of an inlet, ducts, exhauster or blower and a separator. This is practically the same equipment as is required in the methods

*(Please turn to page 454)*

## Manufacturer's Rating Table for Determining Capacity and Other Specifications of Fans

| Fan Size | Diameter of Main—Inches | Load Area Square Inches | SUCTION 3.0 Inches | | VELOCITY 3880 Feet per Minute | SUCTION 3.5 Inches | | VELOCITY 4190 Feet per Minute | SUCTION 4.0 Inches | | VELOCITY 4480 Feet per Minute | SUCTION 4.5 Inches | | VELOCITY 4750 Feet per Minute | SUCTION 5.0 Inches | | VELOCITY 5010 Feet per Minute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Revs. per Min. | Cu. Ft. per Minute | Horsepower | Revs. per Min. | Cu. Ft. per Minute | Horsepower | Revs. per Min. | Cu. Ft. per Minute | Horsepower | Revs. per Min. | Cu. Ft. per Minute | Horsepower | Revs. per Min. | Cu. Ft. per Minute | Horsepower |
| 30 | 12 | 85 | 1496 | 2843 | 6.00 | 1619 | 3072 | 7.43 | 1723 | 3280 | 9.18 | 1833 | 3485 | 11.00 | 1931 | 3670 | 12.90 |
| | 13 | 99 | 1492 | 3320 | 6.24 | 1614 | 3585 | 8.56 | 1724 | 3840 | 10.40 | 1827 | 4070 | 12.50 | 1925 | 4285 | 14.70 |
| | 14 | 112 | 1487 | 3795 | 7.76 | 1610 | 4100 | 9.80 | 1717 | 4380 | 12.00 | 1821 | 4645 | 14.30 | 1918 | 4895 | 16.70 |
| | 15 | 127 | 1485 | 4262 | 8.90 | 1607 | 4605 | 11.20 | 1715 | 4920 | 13.60 | 1820 | 5220 | 16.30 | 1916 | 5503 | 19.10 |
| | 15 | 141 | 1490 | 4749 | 10.10 | 1611 | 5125 | 12.80 | 1720 | 5478 | 15.50 | 1825 | 5830 | 18.50 | 1920 | 6138 | 21.70 |
| 35 | 14 | 115 | 1285 | 3865 | 8.15 | 1390 | 4180 | 10.10 | 1486 | 4460 | 12.47 | 1592 | 4740 | 14.92 | 1658 | 4990 | 17.45 |
| | 15 | 134 | 1282 | 4520 | 9.26 | 1386 | 4875 | 11.63 | 1482 | 5220 | 14.15 | 1572 | 5535 | 17.00 | 1654 | 5830 | 19.90 |
| | 16 | 153 | 1279 | 5160 | 10.57 | 1381 | 5536 | 13.30 | 1478 | 5960 | 16.23 | 1566 | 6320 | 19.36 | 1651 | 6655 | 22.70 |
| | 17 | 172 | 1277 | 5796 | 12.08 | 1380 | 6260 | 15.15 | 1476 | 6690 | 18.52 | 1553 | 7100 | 22.10 | 1649 | 7490 | 25.95 |
| | 18 | 192 | 1280 | 6455 | 13.70 | 1385 | 6970 | 17.30 | 1480 | 7450 | 21.05 | 1568 | 7925 | 25.20 | 1652 | 8340 | 29.45 |
| 40 | 16 | 150 | 1125 | 5050 | 10.65 | 1217 | 5460 | 13.20 | 1300 | 5830 | 16.30 | 1378 | 6190 | 19.50 | 1452 | 6520 | 22.80 |
| | 17 | 175 | 1122 | 5900 | 12.10 | 1214 | 6370 | 15.20 | 1296 | 6820 | 18.50 | 1374 | 7230 | 22.20 | 1447 | 7620 | 26.00 |
| | 18 | 200 | 1119 | 6740 | 13.80 | 1210 | 7280 | 17.40 | 1292 | 7780 | 21.20 | 1370 | 8250 | 25.30 | 1442 | 8690 | 29.70 |
| | 19 | 225 | 1170 | 7570 | 15.80 | 1208 | 8180 | 19.80 | 1290 | 8740 | 24.20 | 1368 | 9270 | 28.90 | 1440 | 9780 | 33.90 |
| | 20 | 250 | 1120 | 8430 | 17.90 | 1212 | 9100 | 22.60 | 1294 | 9730 | 27.50 | 1372 | 10350 | 32.90 | 1444 | 10900 | 38.50 |

NOTE: This table is based on average conditions for one particular type of fan, and takes into account the suction required at the hoods, the friction loss in the piping, ar ' the resistance of the collector. The first column in the table gives the manufacturer's number corresponding to the size of the fan; the third column, the combined area of all the branches; the second column, the required diameter of the exhaust main, which corresponds to an area of 25 per cent in excess of that in column three. All other quantities in the table are clearly indicated. In the layout shown in the sketch on the opposite page, the combined area of the pipe branches to hoods is found to be 147 sq. in. The table shows that this corresponds closely to a 16-in. main, and may be cared for by a Size 35 fan If a velocity of 3,500 to 4,000 ft. per min. is required to carry the material to be handled in this case the speed and horsepower required may be taken with sufficient accuracy from the column headed "Suction 3 in., Velocity 3,880 ft." The table shows that a Size 35 fan should run at 1,279 r.p.m. and will require 10.57 hp. to operate it. This table is only a small section of the fan data supplied by the manufacturer.




**Cyclone separators such as this are used for collecting shavings and other materials where it is not objectionable to discharge fine dust into the atmosphere.**

*Here Are Some*

# Practical Pointers on Winding D. C. Armatures

## *Together With Directions for Taking Data and Marking Armatures to Prevent Errors in Rewinding and in Connecting Leads to Commutator*

By A. C. ROE

*Renewal Parts, Engineering Dept., Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.,*

and

D. H. BRAYMER

*Consulting Editor, Industrial Engineer*

**WHEN REWINDING armatures, careful recording of winding data and the observance of certain rules and principles are essential safeguards against costly mistakes. Furthermore, unless the winding data are put down in some systematic manner so that they will be easy to understand and use, serious confusion may arise and result in errors that are expensive to rectify. In this article, examples are given showing how to use the data forms which were shown in the June and July issues. In addition, there are described some simple methods of taking certain data and marking the commutator and core so as to insure that the armature will be properly rewound and connected.**

IN THE article in the August issue directions were given for the proper use of the forms described and shown in the June and July issues, for taking and recording rewinding data on wave- and lap-wound armatures. In addition, there were also given some handy rules and principles, observance of which will help to prevent mistakes when rewinding and connecting armatures having these types of windings. The present article deals with the methods of taking rewinding data and marking the armature so as to insure that it will be properly rewound and connected.

### Identification Markings for Core and Commutator

The first step in taking winding data is to note the nameplate rating, customer's name and order number; then take the number of bands, width, and size of wire, and any other dimension data deemed necessary for rebanding, such as size of tin strip under core bands, and of the fiber strip on top of the coils to prevent the bands from cutting into the insulation. Next, remove all wire, tape, and core bands, and slot wedges, if used. Then count the number of slots and bars, record these on the data sheet in the proper place, and mentally check the number of bars against the number of slots.

For example, if a four-pole armature has 41 slots and 81 bars, the number of bars being one less than twice the number of slots, this would indicate that a dead coil was used, which should be located and used for checking the lead throw and pitch. On the other hand, if the four-pole armature has 41 slots and 82 bars, an even number, this would indicate that a half-idle bar was used. These points can be checked mentally, while writing down the number of bars and slots. Next, locate the dead or half-idle coil, or if none is used, select any coil and mark the teeth on either side of the slot that contains the *top* half of the coil with two cross marks. (See slot *B* in Figs. 1 *I* to 1 *XII*). Then with an odd number of coils per cell, (Figs. 1 *III* and 1 *V*), or with an even number of coils per cell and a dead coil (Fig. 1 *II* and 1 *IV*) select the middle top lead and trace it out to the commutator and mark the bar to which the lead connects with two center-punch dots as shown in Fig. 1 *IV*, bar *F*. These marks should be placed on the front of the commutator bar near the V-ring.

Next determine whether the winding is progressive or retrogressive. This can be done without knowing the lead pitch as follows: Lift the top lead from the bar just marked and bend it back so that it can easily be picked out again without marking it, and lift two top leads on either side of bar *F*. Then with one test light lead on the top lead that connected to bar *F*, touch the other test lead to the commutator bar on either side of and adjacent to bar *F*. If a light is obtained from the bar to the left of bar *F*, (facing the commutator end of the armature), the winding is retrogressive, and the lead pitch (in bars) will be the total number of bars, minus 1, divided by one-half the number of poles. If a light is shown on the bar to the right of bar *F*, the winding is progressive, and the lead pitch (in bars) will be the total number of bars plus 1, divided by one-half the number of poles. This will locate the commutator lead pitch, *CF*. Call bar *C* No. 1 and add the lead pitch in bars. This will give the number of bar *F*. For example, take the case of a 33-slot, 65-bar, progressive four-pole armature. The lead pitch equals $(65+1)\div 2=33$. Then *F* equals 1+33, or 34. The lead pitch can be checked and also located by lifting the top lead from bar *F* and the two adjacent bars on either side of bar *F*, as explained above, and holding one test light on the top of the lead of bar *F*, with the other test lead on the commutator about half-way around from bar *F*, for a four-pole machine, one-third of the way around for a six-pole, one-fourth of the way around for an eight-pole, etc. Move this test lead back and forth until contact is made with a bar that lights. When a light is obtained, try the bar on either side of the one on which a light showed up. This will indicate any shorts, etc., in the commutator or coil, which would throw the lead pitch check off. A light should be found on only one bar, and this is the bar to which the bottom lead connects. Mark this bar with two dots, as shown under bar *C*, Fig. 1 *IV*. Next, count the bars between *C* and *F*, calling bar *C*, No. 1. If bar *F* is number 35, the lead pitch will be one less than the number of bar *F*, or 34, expressed in bars, or 1-and-35 for laying off coil throw.

In counting the lead pitch on the commutator, care must be taken to

count in the right direction, particularly on four-pole armatures. For a left-hand coil, count from the top lead bar in a clockwise direction around the commutator, and for a right-hand coil count in a counter-clockwise direction. In both of these cases and in all future cases, we will assume that we are looking at the armature from the commutator end.

Fig. 2 shows the possibility of two lead pitches as mentioned above. In Fig. 2, assume that coil *A* with a lead pitch of 1-and-9, is the correct coil (left-hand). If the lead pitch had been counted off in a counter-clockwise direction, as indicated by the figures in the small circles, we would arrive at bar *9*, but the count would be 1-and-8, as shown by the light line marked coil *B*. This is a short pitch which is the winding term for a retrogressive winding, whereas the proper winding requires a long pitch or progressive winding.

Having located the top and bottom lead bars and also the top slots, the next step is to locate the slot in which the bottom half of the data coil lies, or slot *A*, Figs. 1 *I* to 1 *XII*. In some cases the coil can be traced across the back of the armature to the bottom slot. In other cases it will be necessary to lift up enough top coils to be able to trace out the coil and locate slot *A*, which should be marked by stamping an X on a tooth on either side of the slot, as shown. Next, take a piece of string and line-out with it from the center of slot *A* to the commutator, using the center mark in the end of the shaft for a point to insure a straight line from the slot center. Then, if this line falls on a bar, mark this bar with one center-punch mark, as shown in Figs. 1 *I*, 1 *III* and 1 *V*. If the line-out falls on the mica, mark the bars on either side of this mica with one center-punch dot, as in Figs. 1 *II*, 1 *IV*, 1 *VI*, and 1 *IX*. By marking the bars on a line with the bottom slot of the data coil, all chance for a wrong lead pitch is eliminated, as the marked bar, *D*, locates the coil on the proper side of the armature and in the proper relation to bars *C* and *F*. The distance *C D* is the throw of the bottom lead and should be marked as 1-and-12, 1-and-9, etc., as the case may be.

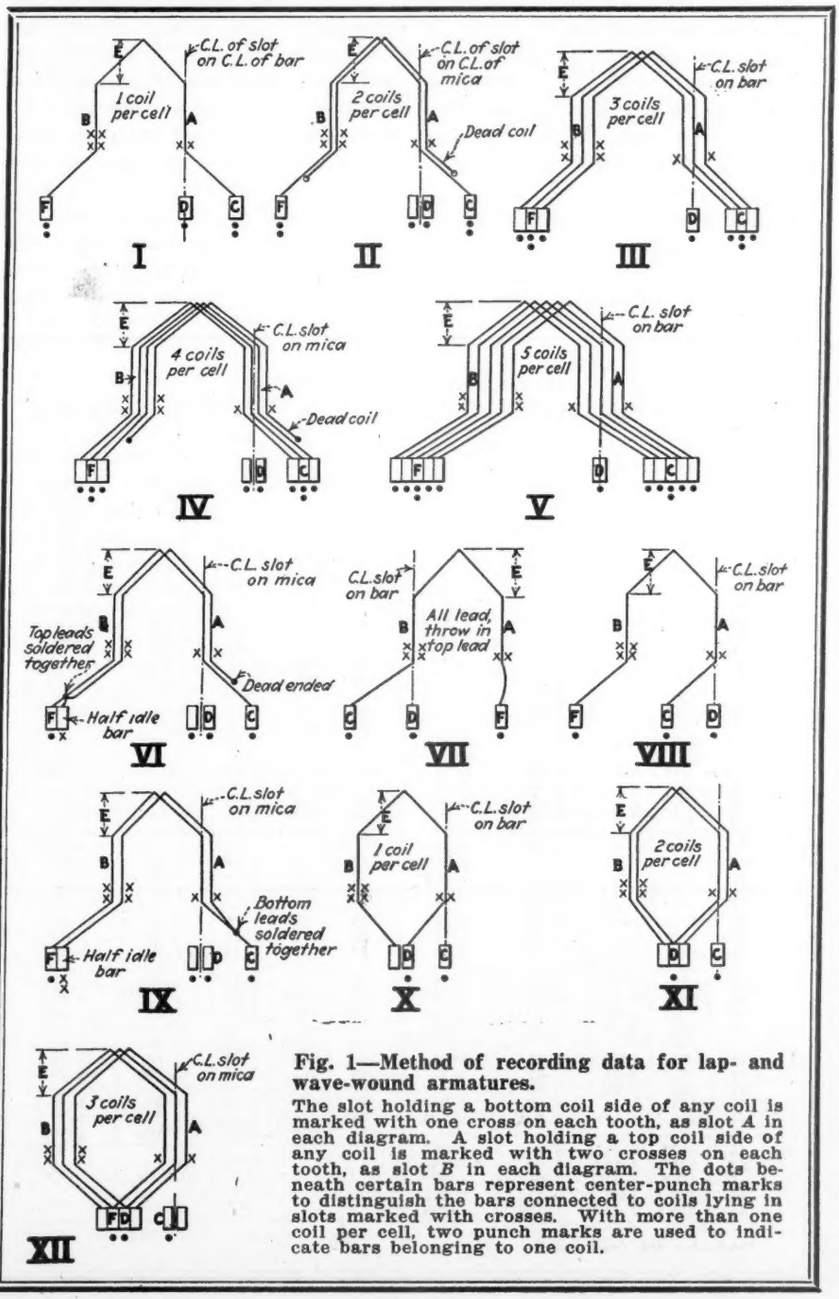



**Fig. 1—Method of recording data for lap- and wave-wound armatures.**

The slot holding a bottom coil side of any coil is marked with one cross on each tooth, as slot *A* in each diagram. A slot holding a top coil side of any coil is marked with two crosses on each tooth, as slot *B* in each diagram. The dots beneath certain bars represent center-punch marks to distinguish the bars connected to coils lying in slots marked with crosses. With more than one coil per cell, two punch marks are used to indicate bars belonging to one coil.

The reason for marking the commutator on a line with the bottom half of the coil and not with the top half is that the winding data are taken in the opposite manner to that used in placing the new coils in the armature. When winding the armature, the first coil has its bottom leads put in the proper bar. If a dead coil or half-idle bar is used, the first coil in should be used to make the required type of idle coil. If the top slot is used to line-out from, the winder would have to put his coil in, then line-out and count over to bar *F*, and then back to bar *C*; but with the marking shown in Fig. 1, as explained above, the winder first locates the marked teeth and puts the bottom half of the coil in the slot between the teeth marked with one cross. He then puts the proper lead in the marked bar. In this way it is not necessary to line-out and count over, as this has been done and the bars permanently located with the core and commutator markings.

After locating the main bars and slots as already explained, mark the bars adjacent to bars *C* and *F* with one punch mark to indicate the number of active coils per slot, and also the position of the data coil in relation to the other coils in the same cell. Figs. 1 *VI* and 1 *IX* show how to mark the bars for a half-idle bar. Two cross marks on one bar indicate that the long jumper is used, as in Fig. 1 *IX*.

For other examples of bar and slot markings, see Figs. 3, 4, 5 and 6, July issue, pages 334, 335 and 336. The accompanying table gives the coil pitch and long and short lead

pitches for the usual numbers of slots and bars used on four-pole machines.

### Method of Checking Lead Pitch for Wave Windings

In what follows an easy method of finding and checking the lead pitch of a wave winding will be given. As already mentioned, the first rule to be memorized is that in any wave winding a series of coils equal to one-half the number of poles will encircle the armature; and this series must end either one bar ahead of or one bar behind the bar that the series started on. This series should never end on the same bar it started on, for then the winding will close on itself the first time around the armature. Then, on any four-pole machine, with a given number of bars we know that a series of $4 \div 2 = 2$, coils, will encircle the commutator, ending on a bar plus or minus one bar from the starting bar.

For example, assume 55 bars and add 1 or subtract 1 from 55. First add 1; then $55+1=56$. The leads of each coil will span a little more than one-half the commutator, or $56 \div 2 = 28$ bars. To check this, call any bar No. 1; then add 28 to it and 28 again to this answer, or $1+28+28=57$. We have only 55 bars, but if we continued counting, bar *1* would be bar *56* and bar *2* would be *57*. Then from this check, if we use a lead pitch of 28, and start the series on bar *1* it will end on bar *57*, or bar *2*, which is one ahead of the starting point and is O. K. Next, subtract 1 from 55, which leaves 54. Then $54 \div 2$ gives a lead pitch of 27 bars, or starting on bar *1* and adding 27 and then 27 again, we arrive at bar *55*, which is one bar behind the starting point and is satisfactory. Thus we find that with a given number of bars on a four-pole machine, there are two possible lead pitches, one long and one short.

Next, suppose we have a six-pole armature having 100 bars and wish to find the lead pitch in bars. With six poles there will be a series of $6 \div 2 = 3$ coils that must end one bar ahead of or behind the start. Then adding 1 gives $100+1$, or 101, and $101 \div 3$ equals 30 2/3 which will not work, since the lead pitch must be a whole number. Next try subtracting 1, or $100-1=99$, and $99 \div 3 = 33$. With a lead pitch of 33, adding to bar *1*, $1+33+33+33=100$. By starting the series on bar *1* and using three coils with a lead pitch of 33, the series will end on bar *100*, which is one behind the starting point, and will result in a retrogressive winding.

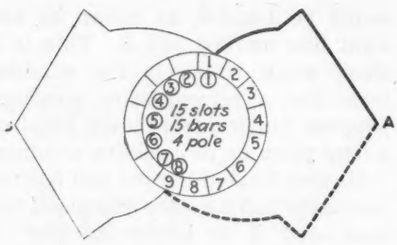



**Fig. 2—This diagram shows how two lead pitches are possible.**

Assume that coil *A* is left-handed and is the correct coil, having a lead pitch of 1-and-9, counted in a clockwise direction. If the lead pitch were counted in a counter-clockwise direction, as shown by the figures in the small circles, bar *9* would be reached, but the count would be 1-and-8 as shown by the coil marked *B*. In the latter case the winding would be retrogressive, whereas it should be progressive. When counting the lead pitch for a left-hand coil, proceed in a clockwise direction, from the top lead bar. When dealing with a right-hand coil, count counter-clockwise.

A progressive two-circuit winding cannot be used with 100 bars, which brings out the fact that on a six-pole machine and with a given number of bars, only one workable, two-circuit lead pitch is obtainable. The reason for using the term "two-circuit" will be explained later.

Next, we will try a six-pole, 200-bar commutator, and try to determine the lead pitch. First try minus 1 or $200-1=199$, and $199 \div 3 = 66$ 1/3, which will not work. Next, try plus 1, or $200+1=201$, and $201 \div 3 = 67$. Then add to bar *1* three times 67, or $1+67+67+67=202$. With 200 bars, No. 202 will fall on bar *2*, which is one ahead of the starting bar, No. 1, and will give a progressive winding. This brings out a condition met with on a six-pole machine; that is, doubling the number of bars will change the winding from retrogressive to progressive or vice versa. If we want to double the voltage by doubling the number of bars, the type of winding will be changed, or we can make the new number of bars equal to twice the old, less one. In the case just mentioned $(100 \times 2)-1=199$ bars, and the lead pitch will be $(199-1) \div 3 = 66$, or $1+66+66+66=199$, which gives a retrogressive winding that will require a dead coil. Thus

## Coil and Lead Pitches for the Number of Slots and Bars Most Used on Four-Pole Armatures

| No. Slots | No. Bars | Coil Pitch | Lead Pitch | |
|---|---|---|---|---|
| | | | Progressive | Retrogressive |
| 23 | 115 | 1–6 | 1–59 | 1–58 |
| 25 | 75 | 1–7 | 1–39 | 1–38 |
| 25 | 125 | 1–7 | 1–64 | 1–63 |
| 27 | 135 | 1–8 | 1–69 | 1–68 |
| 29 | 87 | 1–8 | 1–45 | 1–44 |
| 29 | 115* | 1–8 | 1–59 | 1–58 |
| 29 | 145 | 1–8 | 1–74 | 1–73 |
| 31 | 31 | 1–8 | 1–17 | 1–16 |
| 31 | 61* | 1–8 | 1–32 | 1–31 |
| 31 | 93 | 1–8 | 1–48 | 1–47 |
| 31 | 123* | 1–8 | 1–63 | 1–62 |
| 31 | 155 | 1–8 | 1–79 | 1–78 |
| 31 | 217 | 1–8 | 1–110 | 1–109 |
| 33 | 65* | 1–9 | 1–34 | 1–33 |
| 33 | 99 | 1–9 | 1–51 | 1–50 |
| 33 | 131* | 1–9 | 1–67 | 1–66 |
| 33 | 165 | 1–9 | 1–84 | 1–83 |
| 35 | 69* | 1–9 | 1–36 | 1–35 |
| 35 | 105 | 1–9 | 1–54 | 1–53 |
| 35 | 139* | 1–9 | 1–71 | 1–70 |
| 37 | 73* | 1–10 | 1–38 | 1–37 |
| 37 | 111 | 1–10 | 1–57 | 1–56 |
| 37 | 147* | 1–10 | 1–75 | 1–74 |
| 37 | 185 | 1–10 | 1–94 | 1–93 |
| 39 | 77* | 1–10 | 1–40 | 1–39 |
| 39 | 117 | 1–10 | 1–58 | 1–57 |
| 39 | 155* | 1–10 | 1–79 | 1–78 |
| 39 | 195 | 1–10 | 1–98 | 1–97 |
| 41 | 41 | 1–11 | 1–22 | 1–21 |
| 41 | 81* | 1–11 | 1–42 | 1–41 |
| 41 | 123 | 1–11 | 1–63 | 1–62 |
| 41 | 163* | 1–11 | 1–83 | 1–82 |
| 41 | 205 | 1–11 | 1–104 | 1–103 |
| 45 | 89* | 1–11 | 1–46 | 1–45 |
| 45 | 135 | 1–11 | 1–69 | 1–68 |
| 45 | 179* | 1–11 | 1–91 | 1–90 |
| 45 | 225 | 1–11 | 1–113 | 1–112 |
| 45 | 315 | 1–11 | 1–159 | 1–158 |
| 47 | 47 | 1–11 | 1–25 | 1–24 |
| 47 | 93* | 1–11 | 1–48 | 1–47 |
| 47 | 141 | 1–11 | 1–72 | 1–71 |
| 47 | 187* | 1–11 | 1–95 | 1–94 |
| 47 | 329 | 1–11 | 1–166 | 1–165 |
| 49 | 49 | 1–12 | 1–26 | 1–25 |
| 49 | 97* | 1–12 | 1–50 | 1–49 |
| 49 | 147 | 1–12 | 1–75 | 1–74 |
| 49 | 195* | 1–12 | 1–99 | 1–98 |
| 49 | 245 | 1–12 | 1–124 | 1–123 |
| 53 | 53 | 1–13 | 1–28 | 1–27 |
| 53 | 105* | 1–13 | 1–54 | 1–53 |
| 53 | 159 | 1–13 | 1–81 | 1–80 |
| 53 | 211* | 1–13 | 1–107 | 1–106 |
| 53 | 265 | 1–13 | 1–134 | 1–133 |
| 55 | 55 | 1–13 | 1–29 | 1–28 |
| 55 | 109* | 1–13 | 1–56 | 1–55 |
| 55 | 165 | 1–13 | 1–84 | 1–83 |
| 57 | 57 | 1–14 | 1–30 | 1–29 |
| 57 | 113* | 1–14 | 1–58 | 1–57 |
| 57 | 171 | 1–14 | 1–87 | 1–86 |
| 59 | 59 | 1–14 | 1–31 | 1–30 |
| 59 | 117* | 1–14 | 1–60 | 1–59 |
| 59 | 177 | 1–14 | 1–90 | 1–89 |
| 61 | 61 | 1–15 | 1–32 | 1–31 |
| 61 | 121* | 1–15 | 1–62 | 1–61 |
| 61 | 183 | 1–15 | 1–93 | 1–92 |
| 65 | 129* | 1–17 | 1–66 | 1–65 |
| 65 | 195 | 1–17 | 1–99 | 1–98 |
| 69 | 207 | 1–17 | 1–105 | 1–104 |
| 71 | 71 | 1–17 | 1–37 | 1–36 |
| 71 | 141* | 1–17 | 1–72 | 1–71 |
| 71 | 213 | 1–17 | 1–108 | 1–107 |

*Indicates one dead coil.

on six-pole machines and with a given number of bars, only one, two-circuit winding pitch is possible, and the progressiveness depends upon the number of bars.

Next, consider an eight-pole wave winding, which will have a series of $8 \div 2 = 4$, coils, encircling the commutator, plus or minus one bar from the start. With 199 bars the lead pitch will be $(199+1) \div 4 = 50$, or 1-and-51. For a check, add four times the lead pitch in bars (50) to bar No. 1. Then, $1+50+50+50+50 = 201$, or bar No. 2, which is one ahead of the starting bar and results in a progressive winding. A retrogressive winding is not possible, since $(199-1) \div 4 = 49\frac{1}{2}$. By using a half-idle bar, 200 bars and 100 slots could be used.

Now try 398 bars, or $(398-1) \div 4 = 99\frac{1}{4}$, which will not work. Next try $398+1$; then $399 \div 4 = 99\frac{3}{4}$ which will not wind, either. With 100 slots there would have to be 399 bars, or $(399+1) \div 4 = 100$, or a pitch of 1-and-101, giving a progressive winding which would require a dead coil; or 400 bars and a half-idle bar could be used.

The above points are brought up since they are important when considering a voltage increase with double the number of bars.

The following rules pertain to wave windings with reference to the relation of the coil pitch, coils per cell, lead pitch, and their effect on the line-out.

(1) On four-pole machines, when an odd number of slots is used with an even number of coils per cell, there will always be either a dead coil and one bar less than twice the number of slots, or there will be twice as many bars as slots and a half-idle bar. With an even number of slots and an even number of coils per cell, the above rule will also apply.

(2) With an odd number of slots and an odd number of coils per cell, the resultant number of bars will wind without the use of a dead coil or a half-idle bar.

## Rules That Govern Relation of Coil Pitch, Coils per Cell and Lead Pitch in Wave Windings

(1) On four-pole machines, when an odd number of slots is used with an even number of coils per cell, there will always be either a dead coil and one bar less than twice the number of slots, or there will be twice as many bars as slots and a half-idle bar. With an even number of slots and an even number of coils per cell, the above rule will also apply.

(2) With an odd number of slots and an odd number of coils per cell, the resultant number of bars will wind without the use of a dead coil or a half-idle bar.

(3) For six poles, with an odd number of slots and an even number of coils per cell, or with an even number of slots and an odd number of coils per cell, a dead coil or a half-idle bar will have to be used. When the resultant number of bars can be divided by 3 without a remainder, the winding will be progressive. When the number of bars is not divisible by 3, but the —1 sign will reduce the bars to a number divisible by 3 without a remainder, the winding will be retrogressive and will not require a dead coil or half-idle bar to make it wind.

(4) With eight poles, the number of bars plus or minus 1, with or without a dead coil or half-idle bar, divided by 4, should result in a whole number. This is the deciding factor on windings of motors having eight or more poles.

(3) For six poles, with an odd number of slots and an even number of coils per cell, or with an even number of slots and an odd number of coils per cell, a dead coil or a half-idle bar will have to be used. When the resultant number of bars can be divided by 3 without a remainder, the winding will be progressive. When the number of bars is not divisible by 3, but the —1 sign will reduce the bars to a number divisible by 3 without a remainder, the winding will be retrogressive and will not require a dead coil or half-idle bar to make it wind.

(4) With eight poles, the number of bars plus or minus 1, with or without a dead coil or half-idle bar, divided by 4, should result in a whole number. This is the deciding factor on eight poles and above.

The following rules are used in conjunction with Fig. 3*A*. The lead and coil pitches should be expressed in bars and slots; that is, 55, 7, etc., and not 1-and-56 or 1-and-8, etc.

(1) The center line of the coil will fall on a tooth and bar when the coils per cell are odd, coil pitch odd, and lead pitch even, all three being considered together; or with coils per cell even, coil pitch odd and lead pitch odd.

(2) The center line of the coil will fall on a tooth and mica, with coils per cell odd, coil pitch odd and lead pitch odd, or with coils per cell even, coil pitch odd and lead pitch even.

(3) The center line of the coil will fall on a slot and bar with coils per cell odd, coil pitch even and lead pitch even, or with coils per cell even, coil pitch even and lead pitch odd.

(4) The center line of the coil will fall on a slot and mica with coils per cell odd, coil pitch even and lead pitch odd, or with coils per cell even.

The location of slots *D*, *E*, *F*, Fig. 3*A*, is found as explained for Fig. 2, August issue, page 381.

The method of locating bars *M*, *N*, *P*, and *S* (Fig. 3*A*), is found as explained for Fig. 2, August issue, page 381.

The method of locating bars *M*, *N*, *P*, and *S* (Fig. 3*A*,) is explained in the following rules:

(1) In all cases where the center line of the coil falls on a bar, the number of bar *S* is equal to the lead pitch (in bars) plus one more than the active coils per cell in the bottom of slot *A*, divided by two. Note that the term "active coils per cell" is used. This means that when there are four coils per cell, and a dead coil is used, there will be three active coils per cell in the data coil. The rules for a half-idle bar will be given later.

In the shape of a formula, the above rule becomes [(lead pitch)+(active coils per cell+1)]÷2. For example, consider a four-pole machine with a coil pitch of 1-and-13, or 12, and a lead pitch of 1-and-75, or 74, three coils per cell, 49 slots and 147 bars with no dead coil. With the number of coils per cell odd, coil pitch even and lead pitch even, the center line of the coil will fall on slot *F* and bar *S*. Slot *F* equals $(12+2) \div 2 = 7$. Bar *S* equals $(74+3+1) \div 2 = 78 \div 2 = 39$, and bar *P* then equals 75.

(*Please turn to page 458*)

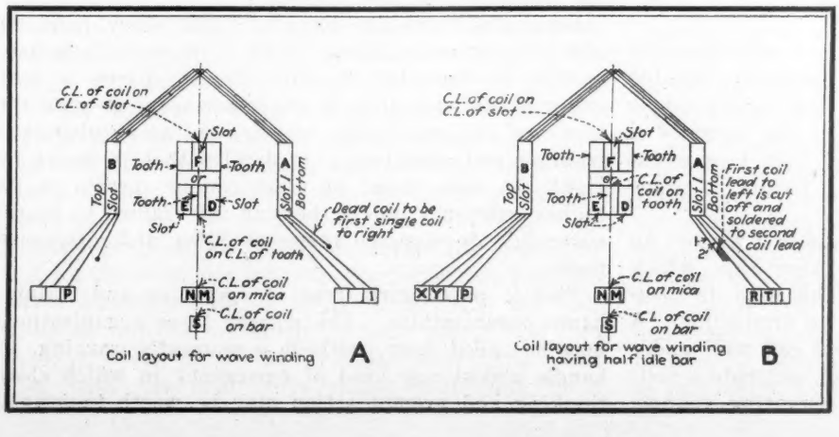

C.L. of coil on C.L. of slot
Slot
Tooth
Tooth
Top Slot
Slot / Bottom
Dead coil to be first single coil to right
C.L. of coil on C.L. of tooth
C.L. of coil on mica
C.L. of coil on bar
Coil layout for wave winding
A
First coil lead to left is cut off and soldered to second coil lead
Coil layout for wave winding having half idle bar
B

**Fig. 3—The location of the commutator, core and coils with respect to each other may be determined from these diagrams, as explained in the text.**

# INDUSTRIAL ENGINEER

*Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories*

G. A. VAN BRUNT
*Managing Editor*

F. E. GOODING
*Associate Editor*

D. H. BRAYMER
*Consulting Editor*

A. J. WHITCOMB
*Associate Editor*


Chicago, September, 1925

## *Now Is the Time to Clean Up Outside Work*

IT IS a good plan to go over the plant now, while the weather is nice, and see that all outdoor equipment is in good condition for the winter. If metal work such as crane tracks, transformer cases, and the like, is to be painted, it is particularly important that this be done in warm, dry weather, in order that the paint may have an opportunity to dry properly.

Yard circuits, comprising power, telephone, fire alarm and other lines should be inspected to see that the wires are not sagging unduly and that the poles or other supports, insulators and so on are in good shape. Ice or sleet and strong winds put a heavy load on wires and their supports, and trouble may be avoided later by taking care of them now.

It is likewise advisable to go carefully over all water, steam, gas, air and other lines and see that any needed repair work, such as stopping leaks and replacing damaged coverings, is done.

Plant buildings should come in for their share of attention, in the way of replacing cracked or broken window panes or skylights, painting fire escapes and other metal work, pointing up the brickwork, and so on.

Outside installation or maintenance work of any sort can be done now in much greater comfort and just as cheaply, if not more so, than later on.

## *Do You Have Trouble Getting Rid of Grounds?*

THE first manifestation of operating trouble on electrical equipment is usually in the form of a "ground," that is a weakening or failure of some part of the insulation of a conductor.

When one side of the line is grounded it throws an additional potential strain on the other side, which before long will result in a short-circuit with its ensuing damage to equipment and delay to production. A series motor having a grounded field coil will, under certain conditions of overhauling load, generate a voltage considerably in excess of the operating voltage, thus endangering the insulation on all nearby equipment. Consequently, the maintenance force should be constantly watching for grounds and upon their appearance should quickly locate and clear them. The frequency with which grounds occur and the quickness with which they are cleared may be taken as true indices of the operating conditions and character of maintenance observed in the plant.

Some operators occasionally ring out the apparatus with a magneto, and let it go at that. Others use a system of lights connected to the bus; while some use a voltmeter which can be plugged between either line and ground. All of these systems have one fault; they depend upon someone focusing his attention on them at the particular time that a ground appears—no automatic record is taken of the appearance of the ground. Since many grounds come and go, it is indeed quite a coincidence when a ground is discovered on its first appearance.

In an article on page 415 of this issue a graphic ground detector is described, which automatically makes a record of all grounds. A system of using the ground detectors so that responsibility for the location and clearing of grounds is definitely fixed, insures prompt removal of this trouble. R. H. Bahney, author of the article, reports that since he installed this system he has been able to reduce the delays on direct-current equipment by 26 per cent. Surely that is sufficient to warrant the investigation of this subject by everyone responsible for the maintenance of electrical equipment in industrial works.

## *Let Your Men Assume Some Responsibilities*

AN executive who is proud of the smoothly-running organization which he has built up, recently decided to take a vacation, for the first time in several years. In order to make sure that the work of his department would be handled satisfactorily in his absence, he purposely kept away from the plant for a day or two, on several different occasions. The results of this test were both surprising and disappointing to him.

In his endeavor to keep mistakes down as low as possible, he had reserved for himself the right to make practically all decisions and oversee all of the details of the work of his department. As a result, his men were not used to assuming any responsibility. They did not know how, or were afraid, to make decisions. In consequence, when he was not there, the work of the department almost stopped.

Such conditions are harmful from every point of view, in any organization. Even if the work is largely routine in character the executive in charge is kept closer to his work than is either necessary or good for him, and the men under him are not being given the training and opportunity to develop that is theirs by right. A department or plant cannot operate at its highest efficiency unless the men are trained to be resourceful: to assume responsibilities and discharge them.

This is particularly true of operating and maintenance organizations. The men in these organizations may be called upon, without a moment's warning, to handle almost any kind of emergency in which clear thinking and prompt action may be worth thousands

of dollars. Failures and breakdowns wait for no one, and unless the men have been properly trained to rely on their knowledge and experience and use their own judgment, an apparently efficient organization may, in the absence of the chief, fail miserably just when its services are needed the most.

One of the marks of a good executive is the ability to train men to take responsibility and fit themselves for the jobs higher up. An honest answer to the question, "How well do your men handle their jobs when you are not there to direct them?" may show you where some reforms are needed in your methods of organizing a department.

### *Covers for Idle Machines Are a Good Investment*

IT SEEMS strange that firms will buy expensive machinery and then neglect to take that care of it which could be obtained for a few dollars. This applies particularly to that great class of machines that is operated seasonally or on special orders and then stands idle for a considerable period, collecting dust. All of this foreign matter must be wiped off before the machine can be put in good operating condition again. In case this is not done the moving parts start up under severe friction loads; often injurious matter is ground into the bearings and may cause considerable damage.

Many plant executives go part of the way, although only part, in this matter of protecting machinery. They allow the operators or helpers time to clean up the machine after the last run. Then the machines will be allowed to stand unprotected until the time comes to run them again. That means that they have to be gone over and coaxed into the same running freedom in which they were when stopped. This may often take nearly as much time as did the original cleaning.

If covers are provided for machines, they can be protected as soon as they are cleaned. When needed again, they are instantly available. One print shop in a small town has a five-month period of idleness for their "big press" which cost them over $20,000. This concern has its maintenance so well directed that after a helper spends two days in cleaning this press from its last run, a slip cover is put over it until the next season opens up.

Canvas or muslin or any fairly closely woven cloth will serve as cover material. Various remnants and odd lots of materials, such as surplus government tarpaulins, that will make good covers, often can be bought cheaply. Covers do not need to fit around a machine, although that is an advantage. A substitute for the fitted cover is a single piece large enough to throw over and drape down the sides or, still better, to be tied around with a cord.

Clean machinery has a higher value than dirty; it adds greatly to the appearance and morale of a plant. The cost of protecting equipment and keeping it clean is trifling, and will be more than repaid in lessened depreciation.

Much has been done to popularize "life extension" and yet the same men who are practicing this for themselves sometimes do not think of applying the same policy to valuable machinery in their plant. This is a phase of maintenance that will bear increasing attention, with the returns in direct proportion to it.

### *Why Burn Lights In the Daytime?*

ONLY too often in industrial plants is lighting thought of as something to be seen and not looked after. Many of us know the shortening of life that results when overvoltage is applied to lamps and everyone will agree that clean reflectors will result in more illumination than dirty ones. Clean reflecting units and correct voltage are two things that must be systematically obtained if efficient lighting is desired.

There is another factor, however, that will result in longer lamp life and saving in energy consumed. We refer to the economy of turning out electric lights when not needed. The importance of this is frequently not realized. It is a needless expense which runs up lighting costs considerably in a plant of any size.

In a case recently brought to our attention it was found that 35 per cent of the larger lamps were left burning when not needed. After a little educational work only about 5 per cent of the lamps were left burning in the daytime. This educational work can be confined to telling everyone to turn out lights when not needed or, better, the job can be delegated to certain individuals in each department.

In the case just mentioned the saving was estimated at 1,440 kw.-hr. per day, or an annual saving of $5,400, which was well worth considering.

### *Test and Maintain Spare Equipment Also*

A RECENT incident in a large plant brings home the importance of maintaining the spare equipment as well as the equipment in service.

In this plant one of the drives requires a direct-current motor of several thousand horsepower and since the drive is of the utmost importance to continuous plant operation it was thought advisable to purchase a spare armature for the motor. This was done and the spare armature was covered with paper, placed in the motor room, and left to take care of itself.

One day the regular armature for this motor failed, with a large shower of fireworks. Investigation showed that the best thing to do was to rewind the armature. Inasmuch as the production of the entire plant depended more or less on this one drive, all haste was made in changing the large armatures. All of the men involved congratulated themselves that they had a spare armature to replace the damaged one, for rewinding this large armature was a matter of a week or more. Much to their surprise, however, shortly after the application of power to the motor the spare armature shorted and grounded in several places. So now instead of having one armature to rewind, they have two, and meanwhile the drive is not in production.

This example illustrates only too well the need of maintaining and testing the spare equipment just as carefully as the equipment that is in service. In fact operating conditions in many cases are not so hard on the electrical equipment as standing idle is. Warm motors, such as those in operation, do not collect moisture, while idle, cold machines do. Spare armatures and other electrical equipment having insulation should be cleaned, painted, and tested just as often and just as thoroughly as the regular equipment.

*Twentieth Annual Convention of*

# Association of Iron and Steel Electrical Engineers

## *To Be Held in Connection With the Annual Iron and Steel Exposition at Philadelphia, Pa., September 14 to 19, 1925*

UNUSUAL efforts have been put forth by President Cummins, Business Manager Kelly and the various committees in charge, to make the 1925 Convention of the Association of Iron and Steel Electrical Engineers better and more interesting than ever before.

President Cummins of the Association of Iron and Steel Electrical Engineers extends in the accompanying letter a most cordial invitation to the readers of INDUSTRIAL ENGINEER to attend this convention which will be held at the Philadelphia Commercial Museum, Philadelphia, Pa., Sept. 14 to 19, 1925. The annual Iron and Steel Exposition, at which a large number of manufacturers exhibit the latest developments in equipment used in the iron and steel industry, will be held in connection with the convention.

There will be a slight change in the usual order of procedure at this convention. Heretofore it has been the custom to hold the business meeting on Monday. This year the program will start at 12:30 p. m., Monday, in with an informal luncheon, at which time everyone who is attending the convention is expected to be present. This luncheon will be held at the Benjamin Franklin Hotel. Meetings on the other days will be held at the Philadelphia Commercial Museum, which will also house the annual Iron and Steel Exposition.

Technical sessions of the Convention of the Association of Iron and Steel Electrical Engineers are scheduled for Monday, Tuesday, Wednesday, Thursday and Friday, Sept. 14 to 19. The subjects that will be discussed at these sessions are as follows:

**MONDAY NOON—SAFETY DIVISION**

**12:30 p. m.—The first session of the Convention will be devoted to the Safety Division, starting with a luncheon at 12:30 at the Benjamin Franklin Hotel.**

**1:30 p. m.—Introduction by A. C. Cummins, President, A. I. & S. E. E.**

**Remarks by L. H. Burnett, Asst. to Pres., Carnegie Steel Co., Pittsburgh, Pa.**

**Remarks by Henry Renninger, Asst. to Pres.. Lehigh Portland Cement Co., Allentown, Pa.**

**How the Electrical Engineer and the Safety Engineer Can Be Mutually Helpful, by John A. Oartel, Chief of Safety Bureau, Carnegie Steel Co., Pittsburgh, Pa.**

**TUESDAY MORNING**

**9:30 a. m.—The Selection and Maintenance of Oil Circuit Breakers, by George A. Burnham, Condit Electrical Mfg. Co., Boston, Mass.**

**11:00 a. m.—The Selection and Maintenance of Oil Circuit Breakers, by M. J. Wohlgemuth, Switchboard Engr., and E. K. Reed, Circuit Breaker Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.**

**1:00 p. m.—Discussion of papers delivered in the morning session.**

**WEDNESDAY**

**9:30 a. m.—Direct Current Armature Windings for Multipolar Generators and Motors—Frog Leg Windings, by W. A. Powell and G. M. Albrecht, Engrg. Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.**

**THURSDAY**

**9:30 a. m.—Electric Heat Treating Furnace Applications, by E. A. Hurme, Manager Steel Mill Division, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.**

**Electric Melting Furnaces, by J. A. Seede, Industrial Engr., General Electric Co., Schenectady, N. Y.**

**Report of Electrically Heated Soaking Pit, in operation at the Donner Steel Co.**

**FRIDAY**

**9:30 a. m.—Auxiliaries and Auxiliary Drives for Steam Electric Generating Stations, by A. L. Penniman, Jr., and F. W. Quarles, Consolidated Gas, Electric Light and Power Co. of Baltimore, Baltimore, Md.**

**11:00 a. m.—Extending the Heat Cycle in Boiler Operation by the Use of Preheated Air for Combustion, by J. G. Worker, Vice-Pres., American Engineering Co., Philadelphia, Pa.**

*Association of Iron & Steel Electrical Engineers*

BOARD OF DIRECTORS—1925

A. C. CUMMINS, President, Carnegie Steel Co., Duquesne, Pa.

G. B. SCHAEFFER, 1st Vice President—Carpenter Steel Co., Reading, Pa.
S. S. WALLS, 2nd Vice President—Carnegie Steel Co., Pittsburgh, Pa.
JAMES FARRINGTON, Treasurer—Wheeling Steel Corp., Steubenville, O.
R. S. SHOEMAKER, Past President—American Rolling Mill Co., Middletown, O.
R. B. GERHARDT, Past President—Bethlehem Steel Corp., Sparrows Point, Md.

W. S. HALL, Director—Illinois Steel Co., South Chicago, Ill.
A. J. STARRING, Director—Bethlehem Steel Corp., Bethlehem, Pa.
C. R. SKELLY, Director—American Steel & Wire Co., Cleveland, O.
J. E. BARRELL, Director—Tennessee Coal, Iron & R. R. Co., Fairfield, Ala.
G. H. McKEHOTT, Director—Illinois Steel Co., South Chicago, Ill.

E. FRIEDLAENDER, Honorary Director, Pittsburgh, Pa.
F. W. CRAMER, Secretary, Bethlehem Steel Corp., Johnstown, Pa.
JOHN F. KELLY, Business Manager—Empire Building, Pittsburgh, Pa.

Pittsburgh Pa.
September First,
1925.

TO THE READERS

OF INDUSTRIAL ENGINEER.

On behalf of the Board of Directors of the Association of Iron and Steel Electrical Engineers, I am extending to you an invitation to attend our Twentieth Annual Convention and Exposition, to be held at the Philadelphia Commercial Museum, at Philadelphia Pa., September 14th to 19th, 1925.

Our Association's activities for the past nineteen years have been directed solely towards the advancement of the application of Electricity to the Iron and Steel Industry and today, we can safely claim that at least 55% of our Industry has been electrified. Provided the trend of the times is any indication it will require about ten years to completely electrify the Iron and Steel Industry.

Your co-operation and interest is earnestly solicited in joining with us at our Convention, helping us, advising us, better ways, better methods, to bring about complete electrification.

Your assistance will be appreciated and your attendance at our technical sessions will be welcomed. You are also invited to visit our Iron and Steel Exposition, being held at the Philadelphia Commercial Museum.

Assuring you that our membership will be glad to provide for your conveniences and comfort while their guests at their Convention, believe us to be,

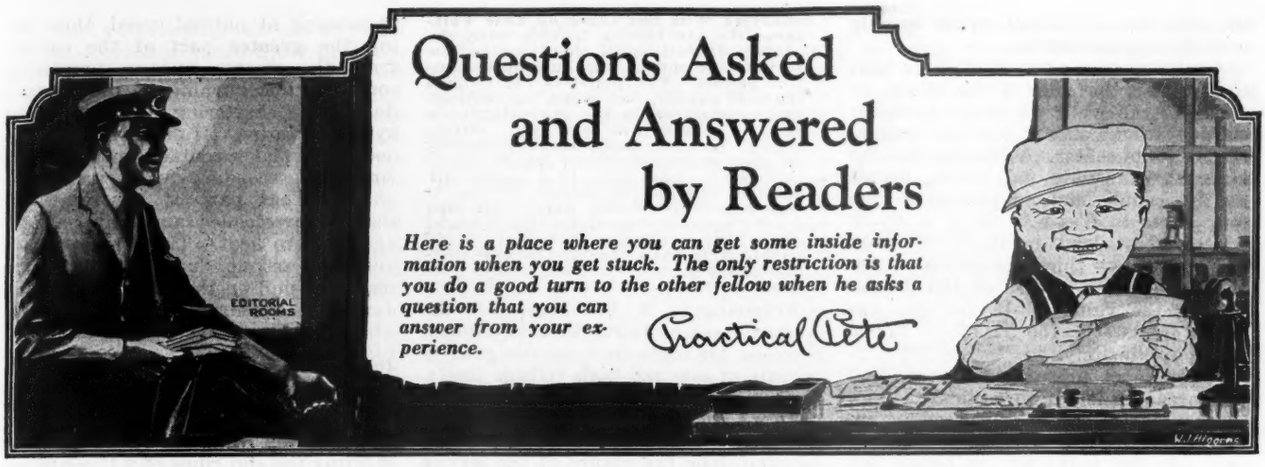
Yours very truly,

President.

It will be noted that the papers to be given at these sessions cover a number of subjects which are of unusual interest. In addition to the program given above, arrangements have been made for inspection trips to a number of steel plants and large industrial works, including the South Philadelphia Works of the Westinghouse Electric and Manufacturing Co.

Industrial plant men can find no better way to aid in the growth and advancement of their professions than by attending and co-operating in the gatherings of their fellow workers when they meet to discuss the problems that confront them all. Such meetings not only aid in the progress of the profession, but also help those who attend and co-operate to broaden their vision and widen their experience.

In addition, an unusual opportunity is afforded at such meetings to make acquaintances and friends with whom an exchange of experiences and co-operation in the solution of new problems as they come up will be mutually profitable. It does every engineer good to get away from the plant for a while and have an opportunity to meet and hear others express their opinions on problems that are of common interest.




# Questions Asked and Answered by Readers

*Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.*

## Who Can Answer These?

**Will Flexible Couplings Reduce Gear Shock on Motors?**—I would like to obtain the views of some of our readers on the value of a flexible coupling in preventing the shock and vibration of gears from reaching the motor armature and commutator. We have encountered some trouble from vibration and gear shock affecting commutators and I am wondering if flexible couplings between the motor and the gear drive would help me in eliminating this trouble.
Omaha, Neb. M. P.

* * * *

**Simple Device for Winding Small Armatures**—I should like to know if any of our readers can tell me how to construct a simple machine that can be made in the shop and used for rewinding small armatures of the fan and vacuum cleaner types. I should also like to know what other equipment is necessary for the rapid handling of this kind of work. Winding these armatures by hand is too tiresome and slow, and we do not have enough of this work to warrant the purchase of an expensive winding machine.
Brooklyn, N. Y. G. A. L.

* * * *

**Transformer for Burning Out Grounds in Conduit.**—I shall appreciate it if some reader will give me data and directions for making a transformer for burning out grounds in conduit. If there is any choice in the matter I can operate this transformer on either 110 or 440 volts, 60 cycles.
Monroe, Mich. C. J. H.

* * * *

**Treating Windows to Prevent Glare.**—I would like to obtain the experience of other readers in treating windows to prevent glare from the sun, particularly on western exposures during the late afternoon. At times this is almost unbearable in parts of our shop. What treatments, if any, have other readers found satisfactory; or would it be better to use shades and, if so, what kind?
Des Moines, Iowa. D. J. C.

* * * *

**How to Determine Horsepower of a Shaft or Clutch.**—Manufacturers of couplings, clutches and other transmission equipment rate their equipment in horsepower per 100 r.p.m. Thus a device that will transmit 10 hp. at 100 r.p.m would transmit 25 hp. at 250 r.p.m. I understand clearly that the horsepower per r.p.m. is the same in both cases. However, it seems to me that the shock to both clutch and lineshaft caused by operating a clutch at 250 r.p.m. would be so much greater than at 100 r.p.m. that a heavier clutch would be required.

I should like to get the opinions of readers on this point. In particular I should like to know what allowances, if any, they make for clutches and other power transmission equipment operating at speeds higher than 100 r.p.m
Grand Rapids, Mich. E. E. H.

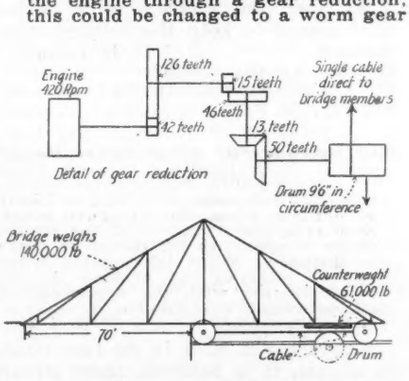
**Why Does One Brush Arc on This Commutator?**—I have been testing some series-wound motors rated at 1/60 hp. These run 1,600 r.p.m. under load and take about 0.4 amp. Speed is governed by a three-ball friction governor. With the governor released, the speed is 7,000 r.p.m., at no load. The motor is connected in series with 180 ohms resistance across a 110-volt a.c. line, thereby impressing about 38 volts across the armature.

We have considerable trouble with the brushes arcing and cutting the commutator. This makes the speed very irregular; so we are trying to improve the commutation. Offsetting the brushes so that they do not track increases the trouble. One brush will arc badly, while the other does not and leaves a very little carbon deposit on the commutator.

The commutator has 36 segments and is 1¼ in. in diameter. We have used several grades of brushes, but the best lasted only 368 hr. If anyone can explain this trouble or help me improve the commutation, I shall appreciate it.
Camden, N. J. L. G. J.

* * * *

**Size of Motor Required to Operate Drawbridge**—I wish to know how to determine the size and speed of motor required to operate a drawbridge that is now operated by a steam engine. The diagram shows the general layout of the bridge. It weighs about 140,000 lb. and travels 70 ft. in 45 seconds. It is supported on four steel wheels 30 in. in diameter with a 12-in. face, running on steel rails. The bridge is pulled back and forth by a steel cable running on a drum which is driven by the engine through a gear reduction; this could be changed to a worm gear




if necessary. The speed of the engine is 420 r.p.m. while the drum turns at 10 r.p.m. I do not know the horsepower of the engine, nor is it equipped to take an indicator card, but the following data may help: Duplex engine (both cylinders receive same pressure); steam pressure, 50 lbs. per sq. in.; cylinders 8 in diameter by 10-in. stroke; speed 420 r.p.m.; non-condensing.

It will be necessary to use a two-phase, 60-cycle, 550- or 2,200-volt motor. I shall be very grateful for any help readers can give me.
Quebec, Que., Can. W. S. B.

## Answers Received To Questions Asked

**Strength of Brick Walls**—We can find very little test data on the strength of brick walls with respect to forces acting against the wall horizontally and at right angles to the plane of the wall. If any readers have pulled down old brick walls they may be able to give me some data regarding the force required.

Suppose we have a brick wall three courses thick, 36 ft. high and 60 ft. long, with no openings and supported at each end by being tied to side walls of the same height and thickness. Assume that this wall has been standing for over a year and was constructed of No. 1 red brick and good mortar, well laid, with header courses placed in the standard manner.

What would be the approximate force required to pull this wall down, assuming the force to be applied at a point half-way up the wall and midway between the ends?
Bowmanville, Ont., Can. L. J. C.

In the June issue, L. J. C. expresses a desire to know what force would be required to pull down a brick wall 13 in. thick, 36 ft. high, and 60 ft. long, which is bonded into side walls. The force is to be applied at the middle of its length and height; that is, at its center.

I do not believe that the wall described can be pulled down by a force applied at its center. It seems to me that a portion surrounding the point of application of the force will be pulled out, due to failure of the mortar joints by a combination of shear and tension. And whether the brickwork above the hole will fall will depend on the size of the hole and the corbelling action of the brickwork.

As L. J. C. says, there are little data on the strength of walls subject to such action as he describes. While numerous walls have been pulled down, few men concern themselves with the precise magnitude of the forces involved. There are abundant data concerning the design, and behavior of retaining-walls, which are subject to loading over the whole area (the resultant pressure being assumed to act at one-third of its height, as on dams), but the forces on a retaining-wall differ vastly from those existing in this case. One could, of course, assume strength values of the brickwork in shear and tension, and reach a conclusion that might be a guide to the strength of

the wall, but the result would be only a rough approximation.

Assuming that a "washer" were used to transfer the pull of the chain, or cable, to the wall, we would have for consideration a slab with a load concentrated at its center. A formula for the strength of square flat plates, loaded at the center and supported on the four edges is $W = .67 \times S \times t^2$; in which $W$ = load in lb., $S$ = fiber stress, and $t$ = thickness of plate. Assuming a "fiber stress" of 150 lb. per sq. in., the value of $W$ for this example is, $0.67 \times 150 \times 13^2 = 17{,}000$ lb., approximately.

I would not presume, however, that the foregoing is within hailing distance of the correct solution. So many unknown factors are involved that a correct solution could not be hoped for. Were the wall free at the ends, and narrow enough to insure its movement as a unit, an approximate solution might be derived from a consideration of the forces producing stability. Even then large errors may arise from ignorance of just at what point above the base the wall will turn over; this point may be, because of varying bond strength of the mortar, anywhere up to about a sixth of the height.

In *The Surveyor*, London, Aug. 20, 1920, there is a report of the Building Research Board, on tests to determine the strength of thin walls loaded on the top and subjected to a horizontal pressure applied at mid-height. The one of interest here was made on a brick wall 4½ in. thick (one course), 3 ft. 6 in. wide, and 8 ft. 6 in. high, laid up in 3 to 1 cement mortar. A vertical load of 1 ton per lin. ft. was applied to the top of the wall with a hydraulic testing machine. The wall was broken by a horizontal load of 895 lb. applied at the middle of its height; the "fiber stress" was 161 lb. per sq. in.

Los Angeles, Calif. C. O. SANDSTROM.

* * * *

**How Does This Motor Start?**—I have a motor made by the General Electric Company that has the following nameplate data: Ser. No. 79,281, type IS, class 4, form A, 60 cycles, 1,800 r.p.m., ½ hp., 110 volts. The nameplate does not say whether the motor is single phase, but as there are only two leads coming out of the machine, I think that it must be a single-phase motor. It has a solid rotor, no starting switch, and no split winding for starting the motor. The winding in the stator is similar to a chain winding. The armature has 36 slots, two of which are empty. The empty slots are spaced seven slots apart. Can some reader tell me how this motor is started from a single-phase power supply?

Oakland, Cal. N. N.

Referring to N. N.'s question in a late issue, the Type IS motor is a single-phase motor which requires a resistance-reactance starter. Such a starter provides the phase-splitting effect necessary for starting the motor. The resistance-reactance is cut out when the motor is brought up to speed. If possible such a motor should always be started light; that is it should be started up disconnected from the load and the load applied after the motor is up to speed. A suitable starter known as the CR-1027 can be obtained from the manufacturer. R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Co.,
Schenectady, N. Y.

**Contactors Will Not Close on Low Voltage.**—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?

Omaha, Neb. M. P.

Referring to M. P.'s inquiry in the August issue of INDUSTRIAL ENGINEER, the coils for contactors are designed to operate at low and high voltage limits. Generally, the contactors operate at 10 per cent above and below normal rated voltage, but the per cent varies depending upon the nature of the service and the kind and make of controller. M. P. does not state whether the supply line is a.c. or d.c., although from his account of the trouble it appears to be a.c. On some d.c. controllers where a protecting resistance is cut in, in series with the coil when the contactor closes, a voltage 30 per cent below normal rated voltage will close the contactors. On some a.c. controllers a voltage 20 to 25 per cent below normal rated voltage is used for test-out.

If M. P.'s controllers operate on d.c., I suggest that he write to the manufacturer giving complete nameplate data and the lowest voltage at which the equipment is to function. If the supply is a.c. he can improve the functioning of the contactors by decreasing the magnetic gap at the outer pole of the switch and the armature lever by 1/64 to 1/32 in., by preventing the armature lever from dropping back the full amount. This, of course, will proportionately decrease the arc gap which will not be serious considering that the contacts have already been worn down to compensate for the readjustment. Since he does not give any voltage values indicating the variations, it is difficult to state whether he is operating beyond the voltage range; if so, then the problem is to devise some means to keep the voltage more constant. E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

**Will Shorting Slip Rings Injure Motor?**—Will short-circuiting the slip rings on a three-phase, wound-rotor, induction motor damage it? This is likely to happen when the external resistance is entirely cut out of the circuit so as to speed up the motor as much as possible. What takes place when one or more of the brushes do not make contact with the slip rings of such a motor?

Milwaukee, Wis. B. R. B.

Answering B. R. B. in the June issue, he should, it is believed, short circuit the slip rings of his three-phase wound rotor induction motor for normal operation. The resistance in the secondary is usually provided for starting under somewhat of a load and for reduction of speed below normal. With the usual starter the slip rings are short-circuited when the handle is turned to the running position. In places where there is much vibration it may be desirable to install an enclosed switch to short-circuit the rings, after the motor is running at normal speed, thus taking the greater part of the current from the starter and so preventing some possible burning of the contacts due to the chattering which is set up by the vibration. If one of the brushes does not make contact with its slip ring the secondary will run single-phase. That part of the rotor will then be overloaded and may be damaged due to heat. There may also be vibration set up due to the eccentric magnetic pull on the rotor which could damage the bearings and in time the whole machine. D. W. BLAKESLEE.

Electrical Engineer,
Jones and Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Answering B. R. B. in the June issue, shorting the slip rings of a three-phase, wound-rotor motor will not in any way injure the motor; it is in fact the full-speed condition of any motor of this type. It is assumed that in B. R. B.'s case an externally-mounted resistance is used, in which event the rings are short-circuited in the controller. Should one or more brushes not make contact, the effect will be noticed in the supply circuit by the unbalancing of the current, and is comparable to the behavior of a motor having resistances of different values in the rotor circuits.

C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
New York, N. Y.

* * * *

Replying to B. R. B. in the June issue, it is not unusual to have a three-pole, single-throw switch mounted on the motor with one side of the switch tapped on at the brush holders and the other side shorted with a suitable piece of copper. When the machine is up to speed the switch is closed and cuts out the external resistance.

If one brush does not make contact with the slip ring the speed will be reduced and in time the motor will heat. If the brushes on two rings do not make contact the motor will stop, as there will be an open circuit in the rotor and consequently no inductive action between the stator and rotor windings.

San Diego, Calif. E. A. FINLEY.

* * * *

In reply to B. R. B.'s question in the June issue, he should experience no trouble in cutting out all of the secondary resistance in a wound-rotor motor, as most of them are designed to operate that way. The resistance is oftentimes used only during starting and when the last point on the controller is reached the motor runs as an induction motor and develops its maximum horsepower. It would not do, however, to discard the grid resistance and permanently short-circuit the rings as, for one thing, the resistance of the rotor would be too low and the motor would not have enough starting torque to start under any appreciable load.

If none of the brushes on one ring is making contact the motor will run at approximately half speed. If one or more brushes do not make contact the effect will depend on the number of brushes there are on each ring; the more brushes there are, the less will be

the effect of dropping out one or more. On small motors where there are, say, only two brushes to a ring, the effect will be more pronounced. In general the effect will be practically the same as though there were a high-resistance rotor in the motor. The slip will be greater than the motor was designed for, with a consequent reduction in horsepower. The remaining brush or brushes will have to carry more than their intended current and will heat more, which will make matters still worse.

It is well to watch the slip rings to see that they run fairly true. If they are badly pitted or have an uneven surface they are likely to cause poor operation, on a fairly high-speed machine. NICHOLAS J. WEISS.
West New York, N. J.

* * * *

Referring to B. R. B. in the June issue, short-circuiting the slip rings of a three-phase, wound-rotor motor will not damage it, as this operation will cause the motor to run as a three-phase, squirrel-cage induction motor. In fact, it is possible to short-circuit permanently the slip rings of a wound-rotor motor and operate it as a straight induction motor, with only a slight loss in efficiency, by means of an ordinary compensator. This may easily be done in emergencies.

When one or more brushes fail to make contact with the slip rings the motor may start with a slow jerking motion, or may fail to turn over and emit a loud, humming noise.
Riverside, Calif. PHIL D. COMER.

* * * *

Referring to B. R. B.'s question in the June issue, no harm can be done by short-circuiting the rings of this motor, as that is the normal running condition. The rings are always shorted through the external resistance, the purpose of which is to cut down the line current drawn and improve the torque at starting, as a higher resistance has that effect.

The external resistance is cut out step-by-step by the controller and an examination of any wiring diagram pertaining to this type of motor will clearly show the short-circuited condition on the last controller point.

If one or more sets of brushes do not make contact, the motor usually will not start or, if it is running, it will roar, overheat very quickly and stall.

The writer has a number of these motors to maintain and usually short-circuits the brushes of a repaired motor, thus enabling it to be started by a compensator in place of a drum-type controller, in the repair shop.
Chief Electrician, JOHN F. BYERS.
Libby Owens Sheet Glass Co.,
Charleston, W. Va.

* * * *

In answer to B. R. B.'s question in the June issue, the motors he mentions are built to run at maximum speed and efficiency with the rotor short-circuited and there is no danger of damage. When the rings are short-circuited these motors have practically the same characteristics as a squirrel-cage motor. In case the resistor and controller become damaged these motors may be short-circuited at the rings and started by the use of a standard compensator of sufficient capacity, although they will not develop very much starting torque when operated in this manner.

If a brush is lifted from a ring while the motor is running the rotor circuit will be opened unless there is a short-circuiting device on the shaft beyond the rings. Opening the rotor circuit will cause the motor to operate single-phase and only one-third of the coils will be active. The rotor will heat badly under these conditions and if run for any length of time the soldered joints would probably come loose and make it necessary to resolder the connections.

Practically all wound rotors of the polyphase type have three-phase windings, regardless of whether it is a two- or three-phase machine, and for this reason care must be taken to see that all of the brushes are doing their work, or the machine will overheat. I have had experience with a great many old, wound-rotor motors using a drum controller for cutting out the resistance. Many of these controllers have insufficient copper contact surface, which resulted in burned out-controllers and damaged rotors. To overcome this difficulty a switch was installed to increase the capacity of the short-circuiting device.

After the controller was put on the last point the switch was closed and made a solid tie across the rotor. Of course, this could not be done with a variable-speed motor, such as B. R. B. is evidently operating, but the brush question is very important and rings and brushes must be kept in first-class condition on wound-rotor motors.
Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

* * * *

In the June issue, B. R. B. asks about short-circuiting the slip rings of a wound-rotor motor. This will not injure it.

When one or more of the brushes do not make contact with the slip rings the resistance of the secondary circuit will be increased, the speed will be decreased and the remaining brushes will have to carry more than normal current per square inch of surface. If none of the brushes on one ring make contact, leaving a single-phase rotor, the torque will be about 60 per cent of normal, the secondary current in each case being the same. If the brushes on two rings fail to make contact the motor is likely to be damaged, unless it is equipped with protective devices.
Hopewell, Va. R. M. BUSH.

* * * *

Replying to B. R. B. in the June issue, a short-circuit on the rings of a slip ring motor will cause no damage, as that is the normal running condition at full speed, even though the short-circuited condition is brought about through the controller. When the resistance is entirely cut out of the circuit the motor practically becomes a straight induction motor and will come up almost to synchromous speed.

When one set of brushes, that is all of the brushes acting on one ring, do not make contact the motor will operate at about half speed and if an attempt is made to carry full load the windings connected to the working rings are likely to be burned out. When two rings are rendered inoperative because the brushes do not make contact, the motor will stop and no damage will be done, as the stator current will drop to the small amount required for magnetizing current only.
Seattle, Wash. W. MONTELIUS PRICE.

* * * *

**Connecting Lineshaft Directly to Motor**—We wish to connect a lineshaft approximately 100 ft. long directly to a 50-hp., 870-r.p.m. motor. The lineshaft can if necessary be supported from the ceiling, but we should prefer to mount it on top or at the side of heavy wooden or concrete posts. This department is on the ground floor and there is no basement underneath the building. I should like to know (1) if it is practicable to drive a lineshaft at this speed. (2) Would it be better to support the lineshaft on the top, or at the sides of the posts? (3) Is there likely to be excessive vibration? If so, how can it be overcome? (4) What kind of bearings should we use? Your advice will be greatly appreciated.
St. Louis, Mo. B. G. S.

In answer to B. G. S.'s question in a late issue, it is my opinion that it would be very difficult to make such an installation give satisfactory service. Driving a lineshaft at 870 r.p.m. would in all probability cause the supports to vibrate considerably and it would, therefore, be hard to support them solidly. Unless the machines driven are of unusual character, the pulleys would have to be rather small, which might allow the belts to slip.

If the motor must be connected directly to the lineshaft the supports for the latter should be firmly anchored to the ceiling and either roller or ball bearings used.

Vibration can sometimes be lessened by placing the driven machines on both sides of the lineshaft, so that the belts also pull from each side.
Peoria, Ill. GEORGE D. RINGNESS.

* * * *

Replying to B. G. S. in a recent issue I would not, for various reasons, consider it to be the best of engineering practice to undertake such an installation as mentioned. However, if this is the only way of getting power in the place desired, I would advise mounting the lineshaft on top of concrete pedestals which I would place about 8 ft. apart.

Also, on the lineshaft I would place three small flywheels, spaced equidistant between the motor and the driven machine. The flywheels need not be large, as their purpose would be to prevent whipping of the shaft, rather than storage of power, although this latter effect might be helpful.

I would advise the use of high-speed, sleeve bearings, in order to cut down the expense. A bearing composed of 16-20 parts tin, 2 parts antimony, 1 part lead, and 80 parts copper, should give good service. The bearings should be well lubricated.

Extreme care must be exercised in balancing and aligning this shaft in order to secure the best results.
West Allis, Wis. EDWARD JAMES.

**How to Use Megger for Testing Insulation of Motors**—I wish some reader would give me a few suggestions on the proper method of using a megger for testing the insulation resistance of motors. I should also like to know what is considered a satisfactory reading when testing 110/550 volt, a. c. and d. c. motors ranging from 5 hp. to 50 hp.
Latrobe, Pa. J. K. W.

Answering J. K. W. in a recent issue, the best insructions for using a specialized instrument such as the megger are those issued by the manufacturer. Assuming that J. K. W. does not have any printed directions on the use of this instrument, the following extracts from James G. Biddle's catalog may be of service to him:

*(a)* To use the megger testing set, place it on a firm and fairly level base and without connections of any sort to the terminals, turn the crank in a right-hand direction at about 120 r.p.m. The pointer should promptly move up the scale and stand over the infinity mark.

*(b)* Short-circuit or place a low resistance between the earth and line terminals. When the crank is turned the pointer should promptly move down the scale to zero.

*(c)* Connect the testing leads to the earth and line terminals. If the leads are held in the hand or touch anything and, while turning the crank the pointer indicates less than infinity, there is a leak somewhere which must be removed, before proceeding with the test. If there is no leak between the leads, you may proceed to test the equipment.

*(d)* Connect the leads to the apparatus to be tested and turn the handle of the megger at the proper speed. While turning observe the position of the pointer on the scale; the reading indicates the value of the resistance under test.

When testing motors that have just been installed, connect the line terminal of the megger to a lead, the commutator or an exposed conductor of the machine, and the earth terminal to the shaft or some bright part of the frame. Test the insulation resistance. On a cold machine this should be at least 1 to 5 megohms. The lower value applies to large machines. Be sure when making the test that all circuits are properly connected. If all of the circuits are not connected together, as in the case of a separately-excited generator, test each circuit or group of circuits separately.

When testing motors in service, the procedure is the same as for a new installation. When a motor is warmed up the insulation resistance will be lower than when cold. For testing 110- and 220-volt apparatus, particularly if it is old, it is best not to use a megger generating over 500 volts unless the insulation resistance has been proven to be quite high. It must also be remembered that when making megger tests the equipment under test must not be live.

The standards of the American Institute of Electrical Engineers require that the insulation resistance of a machine at its operating temperature shall not be less than given by the following formula: Insulation resistance in megohms=voltage at terminals÷(rating in kva. plus 1,000).

This formula applies only to dry apparatus, not oil-immersed.

In the case of a 50-hp., 550-volt motor, this equation would be written: Insulation resistance in megohms=550 ÷50+1,000=0.5 megohms, approximately. In this example I used the rating of the motor in horsepower instead of the rating in kva., but the error introduced thereby can be considered negligible for most purposes.
Fort Worden, Wash. E. I. PEASE.

* * * *

Referring to J. K. W.'s question in a late issue, a constant pressure megger is suggested on account of the electrostatic capacity from the winding to the machine frame. For all machines of moderate size, a megger reading up to 100 megohms will cover requirements.

When holding the megger leads while taking readings, great care must be exercised not to let a leak through the tester give a false reading.

Moderate-sized machines generally show an insulation resistance somewhere between 5 and 50 megohms when cold, but the readings will be much less when the machine has just been taken out of service and is still warm.

After connecting the line terminals of the megger to the collector ring, brush, commutator, terminal of armature winding or field, and the ground terminal to the frame of the machine, the insulation resistance reading is obtained by turning the handle of the megger generator. However, the insulation resistance to ground of a number of connected parts of a machine will be far less than that of the parts taken individually. Likewise, changes in temperature and weather conditions will cause a considerable change in the readings obtained.
New York, N. Y. WM. GLAMEYER.

* * * *

With reference to J. K. W.'s question in a recent issue, the use of a megger for testing the insulation of motors should be attended with caution and the judgment gained through practical experience. The megger is not infallible; that is, a high reading will not necessarily indicate that the windings are in absolutely safe condition. In the case of low-voltage equipment there may actually be in the winding exposed copper or bare spots which may be in such close proximity that although a test under certain conditions would indicate everything to be satisfactory, trouble will develop later on due to temperature changes, causing a gradual shifting or change in the windings. In general, a megger test should be considered as more or less of a qualitative test.

In the standardization rules of the A. I. E. E., the following statements are made:

"The insulation resistance of a machine at its operating temperature shall be not less than that given by the following formula: Insulation resistance in megohms=voltage at terminals÷rating in kva.+1,000."

For example, based on this formula the insulation resistance of a 50-hp., a. c., 550-volt motor would be, using 1 hp. as equivalent to 1 kva.; 550÷50 +1,000=0.523 megohms, or 523,000 ohms.

For safety, d. c. motors should be considered on the basis of 1 kva. per horsepower.

It is further stated in the A. I. E. E. rule that, "the insulation resistance is of doubtful significance as compared with the dielectric strength. It is subject to wide variation with temperature, humidity and cleanliness of the parts. When the insulation resistance falls below prescribed values it can, in most cases of good design and where no defect exists, be brought up to the required standard by cleaning and drying the machine. The insulation resistance, therefore, may afford a useful indication as to whether the machine is in suitable condition for application of the dielectric test."

The foregoing quotations from the A. I. E. E. rules state the case of the sphere of the megger very fully. The dielectric test, of course, refers to a test at a higher voltage. For all a. c. motors, this should usually be twice the normal operating voltage plus 1,000 volts. In the case of a 550-volt a. c. motor, 2,100 volts would be applied on this basis, but it is not uncommon to find 2,500-volts used for this purpose. There are also various modifications of these tests.

In conclusion, it may be said that care and good judgment should be exercised in interpreting the results of a megger test.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
New York, N. Y.

* * * *

Regarding J. K. W.'s question in a late issue, for d. c. armatures and fields when the megger shows a reading of three-fourths to one megohm, the armature should be removed, placed in an oven and baked at 95 to 105 deg. C. for 6 to 14 hr., depending upon the size. Then another test should be taken with the megger, while the armature is still *hot;* if this reading is one and one-fourth megohms, or more, dip the armature while hot in a good baking varnish, and allow it to remain under the varnish until the air bubbles stop coming to the surface. When dipping armatures, keep the commutator up and out of the varnish.

When the armature is too large to dip shaft up, make a shallow pan to hold the varnish, deep enough to allow the varnish to reach below the slots. Then place the pan under the armature, which should be placed between two supports, block up the pan to give the proper depth of varnish and revolve the armature, allowing a portion to soak.

After dipping, bake for 6 to 18 hr. at 95 to 105 deg. C. For the best results use a long, low-heat bake. Also, when a large armature has been dipped in a horizontal position, turn the armature 180 deg. after half the total baking time has elapsed.

Before baking the armature for the first time, clean all oil, grease and dirt, etc., off the windings and front V-rings, paying careful attention to the spaces between the core and coil ends. Use

a soft-hair, bottle-washing brush to clean these parts.

It has been found that a clean and dry winding that shows at least one and one-fourth megohms will stand twice its rated line voltage for a high-potential test to ground, for one minute. Therefore, when an armature after cleaning and baking shows at least one and one-fourth megohms it is worth dipping and baking, and if this process is properly carried out the megger reading and the life of the motor will be greatly increased.

On the other hand, if the insulation is aged or damaged, the readings after cleaning and baking will not be much higher; in fact, in some cases the heat will cause a lower reading. When a lower reading or a reading under one megohm is obtained, after cleaning and baking, it is best to rewind the armature completely—*don't patch.*

After a little experience a man can soon learn to judge whether a motor is worth cleaning and baking by the appearance and condition of the windings.

It is good policy to test every new piece of apparatus when installed and record the megohm readings on a motor card; then take readings every three months and when the readings get down to one megohm or take a sudden drop, investigate at once, for trouble, dirt and oil, etc., will run the readings down. It is surprising what cleaning and baking and dipping will do towards keeping a motor out of the rewind class.

In the case of d. c. armatures that work in oily places, or with bearings that leak oil, the condition of the mica between commutator bars should be taken into consideration when contemplating cleaning and baking. In some cases, when the mica is not too soggy, baking for a long time at low heat, 95 deg. C, will put the commutator into satisfactory condition and make the remainder of the process worth while.

Wilkinsburg, Pa. A. C. ROE.

* * * *

**When Should an Armature Be Scrapped Instead of Repaired?**—I shall appreciate it if readers will give me their opinion on the following: If an armature needs new coils, a new commutator and a new shaft, especially if it is of the type that has the laminations stacked on the shaft, is a repair job, with only the laminations for a base, a profitable undertaking? Also, when should the core be junked and new laminations used?

Chicago, Ill. J. E. K.

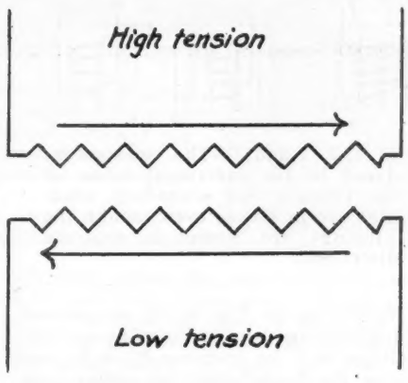
Answering J. E. K. in a late issue, this is a question that can be best settled by consultation with the manufacturer of that particular motor. If the laminations can be removed from the shaft without tearing them to pieces they can be used again, but even under these circumstances they should be treated, annealed and varnished, which is often done to the iron in stators. Under the present-day methods of treating and handling the iron the junking of cores is not so necessary as heretofore. Continual heating of ordinary iron reduces its permeability and increases the hysteresis loss; while silicon steel has non-aging properties that are not affected by heat, ordinary iron can be improved by annealing and varnishing it.

Junking of cores would, then, be considered in the case of iron that was really damaged beyond redemption, or when there was a question as to the feasibility of installing a new armature rather than repairing and replacing the old one. This would be determined by the manufacturer's price for a new core, as compared with the cost of repairing the old one.

West Allis, Wis. EDWARD JAMES.

* * * *

**Polarity of Transformer**—After reading the article on "Checking and Testing Transformer Connections" on page 560 of the December, 1924, issue of INDUSTRIAL ENGINEER, I am somewhat confused as to the relationship between the primary and secondary voltages for transformers of different polarities. Assume a transformer having primary and secondary voltages in the winding as shown by the arrows in the diagram. Can some reader tell me whether this transformer has additive or subtractive polarity, and why?




Chicago, Ill. G. A. V.

As to the question asked by G. A. V., if the diagram indicates the relative location of outside terminals and if the arrows indicate the induced voltages, the polarity is additive.

In many discussions, I have noted that impressed voltage is considered in one winding and induced voltage in the other winding. This leads to unnecessary complications. If all discussion is limited to induced voltages and arrows indicate only induced voltages, then practically all difficulties connected with polarity problems will be avoided. A. BOYAJIAN.

Transformer Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

* * * *

In reply to the question asked by G. A. V. in a recent issue, the transformer in his diagram has additive polarity. The arrows are taken as representing the instantaneous direction of current flow for one half-cycle. In the next half-cycle the direction of current flow in both windings is reversed. The primary current of any transformer induces a flux in the coil of the transformer that lags behind the impressed electromotive force by 90 deg. This flux, in turn, induces a current to flow in the secondary winding that is 90 deg. behind the flux. Therefore, the secondary current lags behind the primary current by 180 deg., or is opposite in phase.

Whether a transformer has additive polarity or not depends upon how the secondary leads are brought out from the winding; in other words, which lead is considered as being the start of the secondary winding. This may also be influenced by the direction in which the secondary winding is wound around the core, relative to that of the primary winding. To have additive polarity, the external wires bear the same relation to the internal windings as shown in your sketch.

F. ELLIOTT WALDRON.

Gloucester Electric Co.,
Gloucester, Mass.

* * * *

With reference to the question asked by G. A. V. in a recent issue, I would say that the marking shown on the sketch accompanying the question is not definite in that we do not know whether the marking indicates the direction in which the windings are wound on the core or the direction in which the currents flow in the winding. If the marking indicates direction of winding, then the transformer is of additive polarity. If it indicates the relative direction of primary and secondary currents, then the transformer is of subtractive polarity.

L. C. NICHOLS.

Engineer in Charge of Transformer Design,
Allis-Chalmers Mfg. Company,
Milwaukee, Wis.

* * * *

Replying to G. A. V.'s question in a late issue, I will say that this transformer has subtractive polarity. It is understood that the arrow shown over the high-tension winding represents the direction of the impressed voltage, while that under the low-tension winding shows the relative direction of the induced voltage, as far as instantaneous values are concerned.

Suppose the transformer in question to be a standard lighting transformer stepping down from 2,200 volts to 220 volts. Let us connect the 2,200-volt side to a 220-volt supply so we can use a plain voltmeter with safety. Since the ratio of transformation is 10 to 1, we would measure 22 volts on the secondary side of the transformer. If we face the secondary side and connect the left-hand primary lead with the left-hand secondary lead and then connect our voltmeter between the remaining primary and secondary leads, we would get a voltmeter indication lower than 220 volts and equal to 220 —22=198 volts, because the voltage induced in the secondary winding is opposed to the normal 220 volts in sending current through the voltmeter. The secondary coil can be considered as a continuance of one leg of the voltmeter to one side of the 220-volt supply, while the other leg goes direct to this supply.

A few years ago, transformer leads were brought out through the tank at random so that even with those of the same make one could not rest assured of the relative polarity without making tests, these tests being always necessary when paralleling transformers of different makes. Nowadays, manufacturers have adopted standard methods in marking the relative high- and

low-tension leads so that transformer paralleling is made easy. These methods are very commendable and can be appreciated by anyone having to connect transformers as boosters or buckers and also when connecting various kinds of meters to potential and current transformers in various circuits.

HENRY MULFORD.

Patchogue Electric Light Co.,
Patchogue, N. Y.

* * * *

In answer to the question asked by G. A. V. in a recent issue, I would say that this transformer has additive polarity for the reason that the currents in the left-hand, high-tension and left-hand, low-tension leads are flowing in the same direction. Therefore, the potential strain between these two terminals is the sum of the voltages in each winding.

If the transformer were of subtractive polarity, the potential arrows in the winding would point in the same direction while those in the left-hand, high-tension and low-tension leads would point in opposite directions. Then the potential difference between these two leads would be the difference between the voltages in the two windings.

This is not a technical explanation, but I believe it may be clearer than one that is technical. L. F. Goss.

Chief Engineer,
Kuhlman Electric Co.,
Bay City, Mich.

* * * *

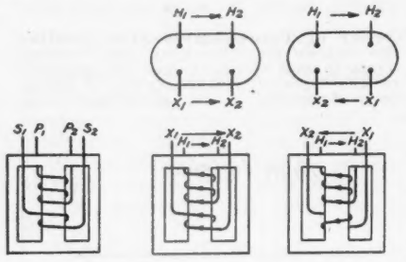
In reply to the question asked by G. A. V. in a recent issue, the transformer in question is of additive polarity. In Vol. 23, No. 5 of the *General Electric Review*, A. Boyajian gives a very thorough discussion of this question. I will try to prove my answer to G. A. V.'s question with an abstract of Mr. Boyajian's discussion.

In Fig. 1 of the accompanying diagram is represented a simple, single-phase transformer. It is of interest to consider the relative direction of the windings and voltages. It will be observed that coil $S_1S_2$ is wound in the same direction as $P_1P_2$, assuming that the first coil starts from the $S_1$ and the second from the $P_1$ leads. On the other hand, the $S_1S_2$ coil is wound in the opposite direction to $P_1P_2$, if we assume that the first starts from $S_1$ and the second from $P_2$. We conclude, then, that whether two coils are to be considered as wound in the same direction, or in opposite directions, depends on which terminals are considered as the start and which the finish. Thus, in Fig. 1, coils $S_1S_2$ and $P_1P_2$ are in the same direction, while coils $S_1S_2$ and $P_2P_1$ are in opposite directions.

Since the primary and secondary induced voltages are induced by the same flux, they must be in the same direction in each turn as is shown in Figs. 2 and 3.

However, whether they will appear in the same or opposite direction as viewed from the terminals depends on the relative directions of the windings. Thus, in Fig. 2 voltages $H_1H_2$ and $X_1X_2$ are in the same direction and in Fig. 3 voltages $H_1H_2$ and $X_2X_1$ have opposite directions. Also, in Fig. 2, voltages $H_1H_2$ and $X_2X_1$ are in the opposite directions and in Fig. 3 voltages $H_1H_2$ and $X_1X_2$ are in the same direction.

When the induced voltages of the high- and low-voltage sides are in opposite directions as in Fig. 3, the polarity is said to be additive; and when the induced voltages are in the same direction as shown in Fig. 2, the polarity is said to be subtractive. The reason for this nomenclature will be evident from the following :




**Figs. 1, 2 and 3—The voltages induced in the individual turns of the primary and secondary windings are in phase, even though the windings are wound in opposite directions.**

Referring to Fig. 2, if we connect a high-voltage lead to the adjacent low-voltage lead, for instance $H_2$ to $X_2$, and excite the transformer on either side, the voltage across the leads, $H_1$ to $X_1$ will be the difference between the voltages of the two sides. Following the voltage from $X_1$ to $X_2$, thence to $H_2$ and then to $H_1$ it is evident that the voltage $H_2H_1$ will oppose the voltage $X_1X_2$, and the polarity is subtractive.

Referring to Fig. 3, which shows primary and secondary induced voltages in opposite directions, if we connect an $H$ lead to the adjacent $X$ lead, for instance, $H_1$ to $X_2$ and excite the transformer, the voltage across the other leads, that is, $H_2$ to $X_1$ will be the sum of the primary and secondary voltages, for reasons explained in the previous paragraphs. Hence, the polarity is additive.

Engineering Dept., FRED W. PAFFEN.
American Cellulose & Chemical Mfg. Co.,
Cumberland, Md.

* * * *

In answering G. A. V.'s question in a recent issue, it is assumed that the direction of arrows is given for the voltage impressed on the primary and the induced voltage received at the secondary terminals. In this event, the transformer is described as having subtractive polarity. However, if we are considering the arrows as indicating the direction of induced voltage in primary as well as in secondary, then the polarity is additive.

Since induced and applied voltages are in direct phase opposition, it is apparent in speaking of voltages that it is necessary to specify whether impressed or induced voltages are being considered.

It is undesirable to consider the impressed voltage in the primary and the induced voltage in the secondary, since it is not always certain which is primary and which secondary and, furthermore, polarity and phase rotation are independent of which winding is primary and which secondary. It is the simplest, clearest, and most logical procedure, therefore, to consider only the induced voltage relation.

Since the primary and secondary induced voltages are induced by the same flux, they must be in the same direction in each turn. Whether they will appear in the same or opposite directions as viewed from the terminals, depends upon the relative directions of the windings. When the windings are similarly wound, the resultant polarity is subtractive. The reverse condition, with the windings wound in opposite directions, gives rise to additive polarity.

Schenectady, N. Y. CECIL H. GREEN.

* * * *

With reference to the question asked by G. A. V. in a recent issue, the sketch in question shows the transformer as having additive polarity. The arrows indicate relative induced voltage in primary and secondary. With the arrows indicating these voltages they will combine in the same manner as vectors; that is, if one vector begins at the terminus of another vector, then the magnitude from the beginning of the first vector to the terminus of the second, would be the sum of the two. The vectors are obviously combined in this manner in the sketch referred to, when two terminals at the same end of the transformer are connected together, (that is, the terminus of one vector is connected to the beginning of the second vector) and the voltage between the other ends of the windings then would be the difference between the beginning of the first vector and the terminus of the second which is obviously the sum of the two. As pointed out in the article in the December issue of INDUSTRIAL ENGINEER, and particularly in Fig. 2 of that article, when the voltages of the two windings add, the transformer is considered to have additive polarity. J. F. PETERS.

Transformer Engineering Dept.,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

* * * *

Referring to the question asked by G. A. V. in a recent issue, in which a diagram of a transformer with arrows pointing in opposite directions on the high- and low-voltage sides is shown, the transformer may be taken as having additive polarity. These arrows, however, are sometimes misinterpreted.

The flux in the core of the transformer induces both the high- and low-tension induced voltages. Because of this fact these two voltages must be in the same direction in each individual turn of both windings. If the windings are wound in such a manner relative to each other, or the leads are brought out in such order that the direction of the induced voltages at the leads of both windings is the same, the polarity is subtractive. If the induced voltages are in opposite directions, the polarity is additive. It should be remembered, however, that the induced voltage on the secondary side of the transformer is in the opposite direction to the impressed voltage from the line or generator.

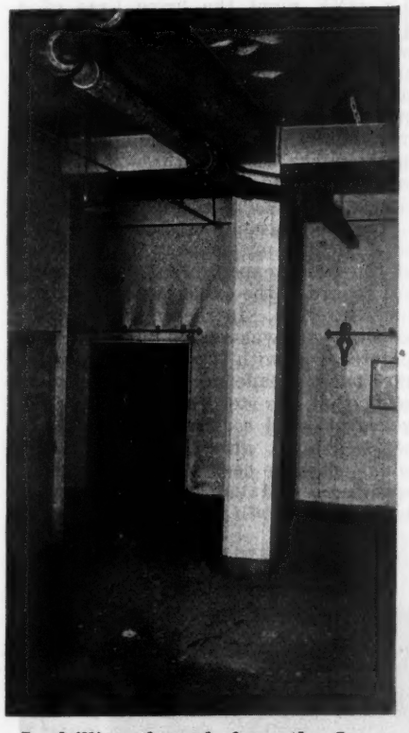
New Orleans, La. OVIDE C. HARRIS.

# Building Maintenance and Plant Safety

*The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.*

## Shoring Up Ceiling as Safeguard When Cutting Holes

ONE of the important jobs of millwrighting in any industrial plant is the erection of motors, countershafts and other equipment on the ceiling. A common method of doing this, particularly for heavy pieces, is to drill a hole through the concrete ceiling from the floor above, countersink for the washers used under the bolt heads in the floor and patch them over. In cutting down through the floor with either a chisel or an air hammer, the ceiling of the room below is likely to chip or break out unless it is shored up from below. This is usually done by placing a short plank against the ceiling and holding it up with an upright wedged tightly in place. Frequently the upright alone is used and the hole is drilled down into the end of the upright. In addition to protecting the appearance of the ceiling, this shoring also prevents any large pieces of concrete from falling and injuring anyone who might be passing underneath.



**In drilling through from the floor above large pieces of concrete were knocked from the ceiling.**

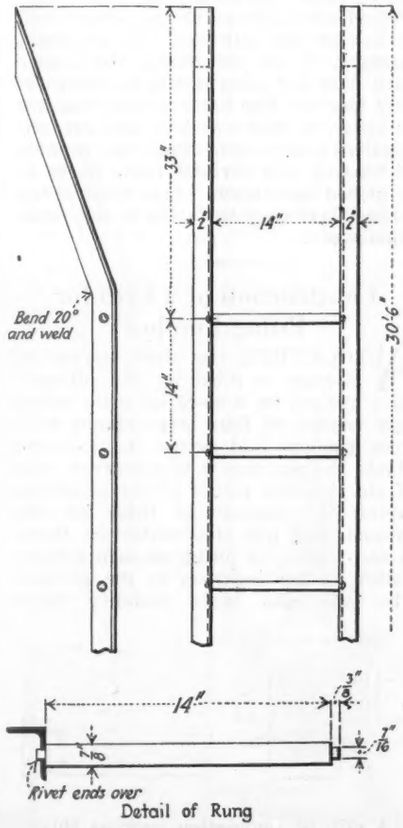
This is not necessary when drilling holes in the ceiling for erecting motors or other equipment. Shoring up from underneath will not only prevent concrete from breaking out around the hole in the ceiling but will also eliminate any possibility of accident to those who may be passing below.

In one plant, where considerable effort has been made toward safeguarding the workers and to teaching all employees to be careful, a photograph was taken showing the result when the shoring was neglected. This photograph was posted on the bulletin board with a notation telling that pieces weighing three to four pounds had fallen from the ceiling and might have seriously injured anyone who happened to be passing. This was followed by a reminder that such accident hazards could be prevented by shoring underneath.

## Substantial Metal Ladder for Industrial Uses

IT IS surprising how often designers who are not familiar with the operating side of industry leave out some features essential to operation. One example of this was in connection with several outdoor transformer stations. When ready for use it was discovered that there was no way to get to the several levels of the structures except by the wooden ladders which had been used in construction. It was found that ladders had not appeared in the original specifications. As the contractors had received their final O. K.'s, and moved away, it was necessary to provide ladders, which were made as shown in the accompanying illustration.

The vertical distance to be covered was about 30 ft. Rungs were not required at the top, but the sides had to pitch inward at the top, as shown in the sketch, to a fastening and also to allow clearance for a man's body from an iron walk, or grille, to the ladder.




**This type of ladder may be easily built and installed.**

Where it is necessary to erect ladders around outdoor transformers or machinery this form of angle-iron construction may be built in almost any shop. The strength of this form of construction and the ease with which it may be adapted to any structure and installed, make it useful around industrial plants.

The sides of the ladders were made of 2½-in. by 2-in. angle irons which were set with the short leg facing the climber. As only 20-ft. lengths of angle iron were available the ends of two pieces were butted and welded. These welded spots were staggered, so that on one leg the weld was 10 ft. from the bottom and 20 ft. on the other. This gave the full length required and also made a neat, smooth job without splicing.

At the top, where the slant came, welding was again resorted to. A V-shaped piece was cut out of the 2½-in. leg, but not through the 2-in. leg. The angles were then bent cold by hand and held at the correct angle, while the cuts were closed up with the welding torch.

The holes in the angles for the rungs were laid out on 14-in. centers, center-punched and the 15/32-in. holes punched on a large punch press. The rungs were made from pieces of mild steel, as shown in the detail drawing. After they had been cut to length, they were then chucked on a Jones and Laughlin turret lathe and a shoulder turned on each end. The rungs were inserted, one side at a time, and cold riveted with a peen hammer.

It is common practice to make ladders used around public service installations and machinery out of two steel flats and with rungs similar to those shown here. However, the ladders described are superior to the others both as to cost and stiffness. To get equal strength in all directions, the ladder with flats for sides would be considerably heavier. The ladders described are as cheap to make as any and are unusually rigid, easy to climb, and capable of bearing any vertical loads likely to be placed upon them. Also, their shape makes them easy to fasten to any steel framework.

## Construction of a Crib for Piling Lumber

ALTOGETHER too often, lumber in storage is piled by the hit-and-miss method on a so-called crib, which may consist of four large stones with some timbers laid across it. In some plants the practice is to construct rails of old ties and pieces of old planking, laying the poorest of these on the ground, and pile the lumber on them. A bad feature of piling on such a foundation is the nearness to the ground. The pile also lacks stability when erected on such a foundation. When a pile of lumber is placed on such a makeshift foundation the air does not circulate around the lower tiers.

The prevalent idea is that the main thing to do in piling lumber is to "stick" it; that is, to place cross-sticks between every layer or two so that air can circulate. Lumber must have this circulation of air to air-dry and, if outside, to keep it free from the damaging effects of moisture when piled tightly.

The weight of a pile of lumber is so great that it causes any temporary crib laid upon average ground to settle. This sinking has a deleterious effect on the lumber that is not generally considered. When piled on an uneven surface for a year or two, lumber that is drying out will take a permanent set. Often at least a foot has to be cut out at the bend and thrown away.

Where the supports of a pile are much shorter than the lumber there is considerable overhang at the ends. This means that these ends assume a permanent droop and have to be cut off before the major part of the piece is available; this lowers the grade of that particular piece and represents a loss on the purchase price. Ends with a long overhang will take this set even if there is no weight on top of them.

The accompanying illustrations show a method of storage that avoids all the ills cited above. This consists of a permanent cribwork made of concrete and steel. The details are shown in the drawing. The first cost of such a crib is considerably higher than the hit-or-miss kind, but it is the cheapest in the end.

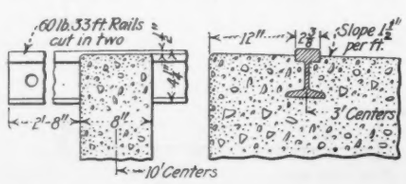
Old rails, cut in two, are used. Any weight of rail that can be picked up locally is strong enough for all the timber that can be piled upon it. Worn-out rails are available in all localities and can usually be picked up at a fraction of the price of structural steel. Rails have a broad base and a good shape to imbed in concrete, with a broad, slightly rounded top. The slope of 1½ in. per ft. to the concrete foundation is about what should be given to any lumber pile in order to make it shed water. The rails also are tipped to correspond to this slope.

The depth to go for the foundation depends on the land where the lumber is stored and upon climatic conditions. A 1-3-6 mixture is strong enough for this work if the upper surface is faced with a richer mixture or troweled off with neat cement to offer greater resistance to wear. By using a taper board under the level to give a uniform slope one way and by leveling the rails, a crib that offers a flat upper surface may be made with a little extra care.

Such a lumber crib is a permanent investment. It does not have to be remade every time the pile is used up, nor do fresh sticks have to be obtained to make up for those that have rotted or been crushed. The time and expense of rebuilding the crib every time a car of lumber is received would go a long way toward the cost of the permanent installation. Also, piles of greater height are possible because of the added stability and strength. This is a factor where space is limited. The most important improvement, however, is the upgrading of the lumber itself. For example, if 10 per cent of a pile containing 5,000 ft. is lost through bending and warping, a charge of $50 or more is laid directly against the cheap crib. Boards that are crooked or warped can be placed at the bottom of the pile and, since the foundation is flat, the weight of the material above will tend to straighten them.

It is worth while to conserve lumber in this way, whether it is to be used for packing boxes or for making furniture.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.




**A crib or foundation such as this, saves lumber.**

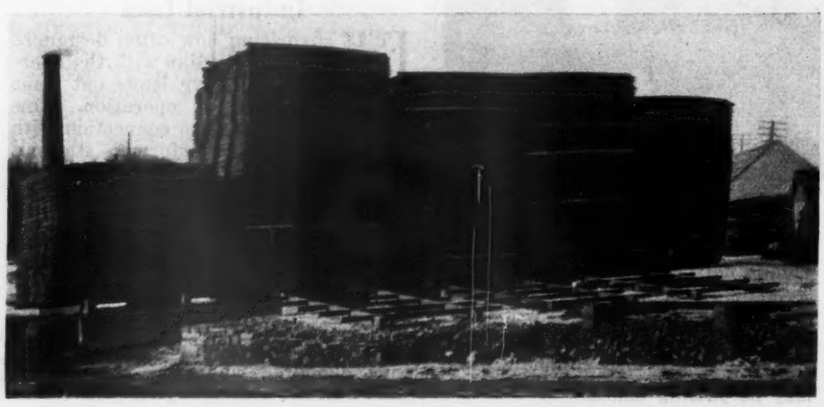
If lumber is piled on a crib like this it not only has a free circulation of air under and through it so that it does not rot at the bottom of the pile but also keeps straighter. The details of the construction are shown in the sketch above. Several piles of lumber, together with some sections of the foundation which are empty, are shown at the right.

## Protecting Hair Felt Insulation on Refrigeration Lines

IN ONE plant the brine lines of a refrigeration system were insulated with hair felt, but the only protection against hard usage was a tar paper covering, held on with twine. Frequently the paper was torn and on making inquiries it was found that the maintenance costs of these lines were extraordinarily high, owing to the continued replacement of this tar paper.

The suggestion was made to have a canvas cover put on, but the objection of the added expense was raised without regard to the expense already regularly involved. In the end, however, a muslin cover was agreed on. This, when painted over with two coats of a special tar paint, made a good impervious cover that has stood up for nearly two years of hard service. Besides being serviecable, it also looks neat, which could not have been said of the former covering.

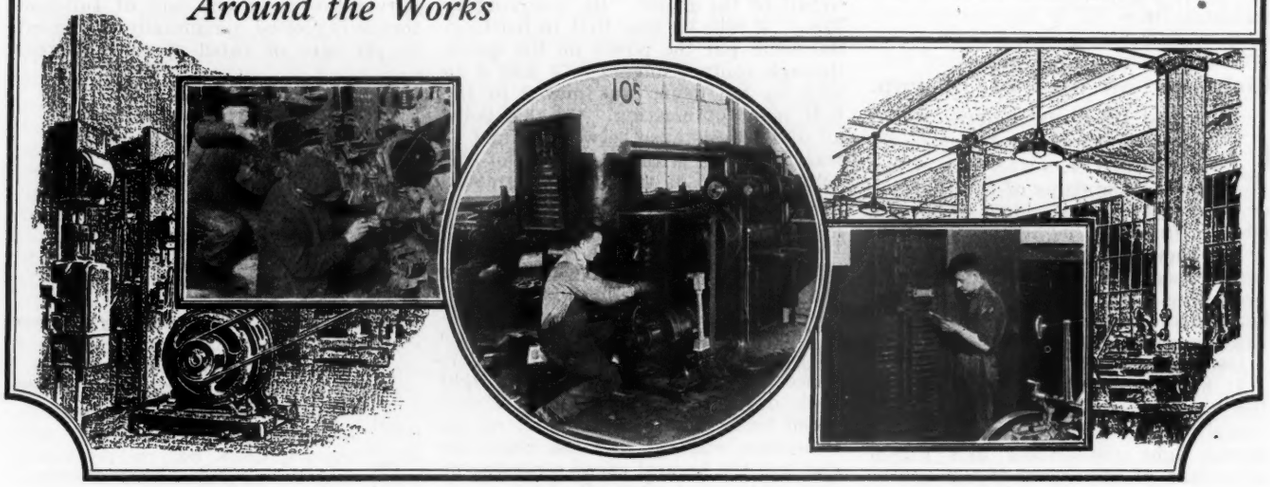
MAURICE C. COCKSHOTT.
Los Angeles, Calif.



# Electrical Service

## *Around the Works*

*For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.*



### Device for Warning Crane Operators of Overhead Wires

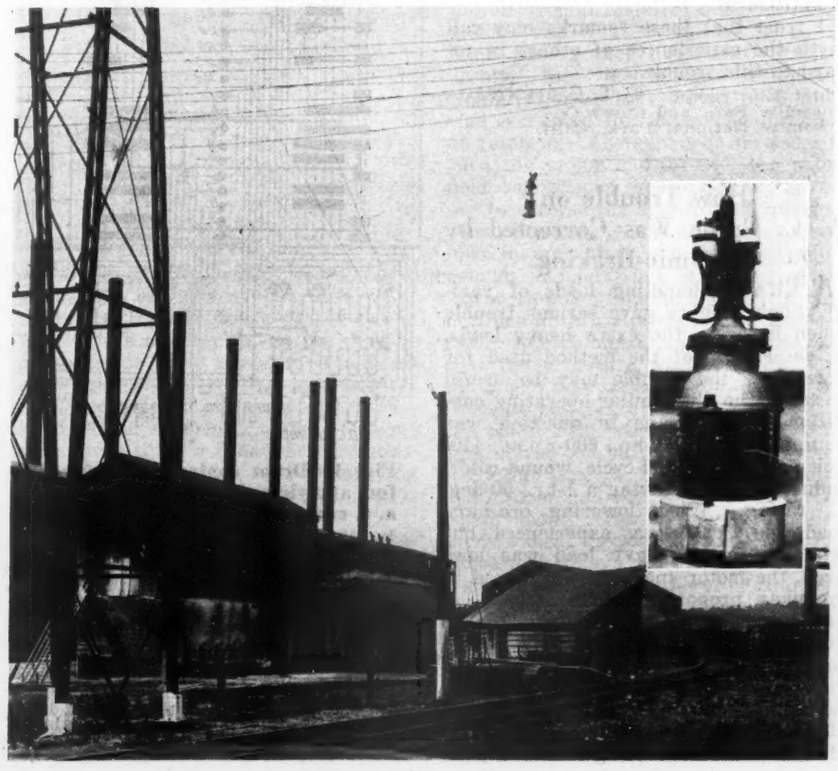
MOST industrial plant yards, and in particular many steel plant yards, have overhead lines which carry the electric power, light, telephone and signal service throughout the plant. These lines are constantly menaced by the booms of locomotive cranes wherever the wires cross over the plant railroad tracks. In the daytime the operator can usually see the wires overhead and take steps to insure that his boom does not tear them down, but at night or in twilight or fog, he cannot readily see the lines.

One plant has endeavored to remedy this trouble by installing a red warning light over the railroad track wherever wires cross overhead. A large number of these lights have been installed making a system of signal lights which has worked out very satisfactorily as it has practically eliminated the breakage of overhead transmission lines from this cause.

There are several features of this installation that are of particular interest. We felt that if we put in warning lights we must be sure that they always burned, for we knew that the locomotive crane operators would rely entirely on the lights to warn them of wires overhead. If the lights failed to burn at twilight or at night, we could almost count on a locomotive crane ripping down wires somewhere in the plant. Hence, we decided that each warning light should contain two lamps, operating in parallel, so that in the case of the failure of either lamp, the second would still be lighted, thereby allowing ample time for replacement of the damaged lamp.

A Nichols-Lintern universal signal lantern, such as shown in the accompanying illustration, was used for the warning light. The lantern has a cylindrical ruby glass lens enclosing the sides and a ruby round lens in the bottom. It is equipped with two lamps; one is a 100-watt lamp which is focused back of the cylindrical lens, and the other is a 50-watt which is focused over the bottom lens. Should either lamp fail, the other will effectively perform the double duty until the defective lamp is replaced. Hence, the lantern throws a strong red light on all sides as well as a red patch of light directly on the ground below.

It is essential that the lanterns be inspected daily to find out whether one of the lamps has burnt out. To facilitate this inspection, cleaning, and replacement of lamps, the lanterns were hung on Thompson (Thompson Electrict Co.) safety lowering switches or disconnecting hangers, as shown in the accompanying illustrations. A steel messenger cable, such as is used to support lead sheath telephone cables, is stretched between poles or adjacent buildings so that the hanger may be fastened to the messenger in position over the track, as shown in the larger



**A red light suspended over the track wherever wires cross it warns the operator to lower the crane boom to prevent damage to wires.**

A Nichols-Lintern warning lantern is hung from a Thompson safety hanger attached to a steel messenger, as shown in the illustration at the left. At the right a close-up view is shown of the lantern and movable part of the safety lowering switch as they appear when lowered to the ground for inspection and lamp replacements.

illustration. With this arrangement of cable and hanger the lantern may be disconnected from the circuit and readily lowered to the ground for any inspection or lamp replacements.

Chief Electrician, R. H. BAHNEY.
The Central Steel Co.,
Massillon, Ohio.

## Comment on Use of 30-amp. and 60-amp. Fuses

ON PAGE 348 of the July issue of INDUSTRIAL ENGINEER, Chas. C. Cobb, Jr., complains of the charring or burning of the cartridges of 30- and 60-amp. fuses.

The company with which I am connected uses about 2,000 of these fuses, protecting 3,000 kw. connected load of heating and cooking equipment. These fuses operate under a 24-hr. load with a load factor of .78.

It has been our experience that if the proper care is exercised in the initial installation of the cutout, as regards tight connections and proper alignment of clips, and if non-renewable fuses are used, the trouble mentioned by Mr. Cobb is negligible.

We have tried to use various makes of renewable fuses and find that they will not carry over 50 per cent of the rated cutout capacity continuously unless such elaborate care is taken at each renewal that the purpose of such a fuse, (quick and cheap renewal) is defeated.

If, for any reason, a fuse has become so hot as to burn the cartridge a great deal of future trouble will be saved if the entire cutout or at least the fuse clips can be renewed for, as Mr. Cobb points out, the causes of such a failure are cumulative and it is certain that the next fuse will do likewise unless the cutout is given the attention that such an important piece of apparatus is entitled to.

I trust that these remarks may call forth the experiences of others in regard to this trouble.

Chief Electrician, E. T. CARPENTER.
Yosemite Park and Curry Co.,
Yosemite National Park, Calif.

## How Trouble on A. C. Crane Was Corrected by Dynamic Braking

A CRANE handling loads of various weights gave serious trouble when lowering the extra heavy loads. A description of the method used for correcting the trouble may be useful to others having similar operating conditions. The crane in question was equipped with a 60-hp., 600-r.p.m., 440-volt, three-phase, 60-cycle, wound-rotor, induction motor having a 1-hr., 50-deg. C. rating. When lowering ordinary loads, no trouble was experienced, but when an extra heavy load was lowered, the motor speed was increased to runaway proportions. On several occasions, the excessive speed caused the rotor to burst with resulting damage to the stator. Heavy bands on the rotor corrected this trouble temporarily, but it was considered advisable to limit the motor speed to such a degree that there would be no danger of a repetition of this trouble. Furthermore, some of the heavy loads had to be deposited on the floor very carefully.

The operation of the hoist motor had been controlled by a drum controller which varied the resistance in the rotor circuit of the motor. By referring to Fig. 1, it will be seen that in hoisting, the drum put the power on the stator through contact fingers *3*, *6* and *9* as soon as the drum was moved to the first point of hoisting. On this point all of the resistance between $R_7$ and $R_8$ was in series with one phase of the rotor circuit. As the drum was moved toward the eighth point, resistance was inserted in the other two phases and then gradually cut out until on the eighth point all of the resistance was cut out, thus giving the highest hoisting speed.

The same arrangement was in use on the lowering side of the controller; hence the motor would drive the light hook down under power, the slowest speed being obtained when all of the resistance was cut into the rotor circuit and the highest speed occurring on the eighth point when all of the resistance was cut out.

With a heavy load on the hook, the situation was, however, quite different. In this case the load pulled the hook down and overhauled the motor, thereby causing it to speed up. As soon as the speed became greater than the synchronous speed of the motor, the latter acted as an induction generator and pumped power back into the line. This action served as a brake, preventing the motor from attaining a higher speed. Under these circumstances the slowest motor speed and the greatest braking effect occurred when the resistance was all cut out, as on the eighth point of the lowering side of the controller. The speed-torque curves shown at *C* in Fig. 2 show the speeds that may be attained in lowering when the hook load is sufficient to overhaul the motor. In these curves torque in per cent of full-load torque is plotted horizontally and speed in per cent of rated speed is plotted

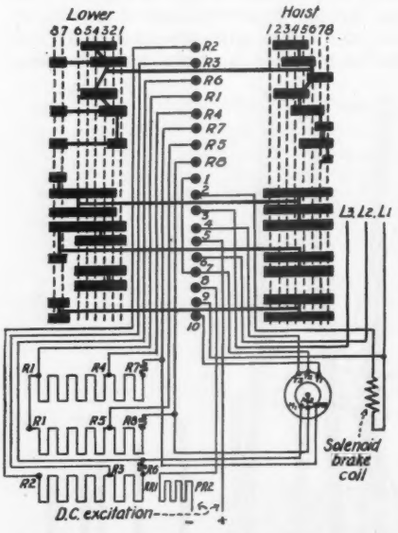



**Fig. 1—Drum controller arranged for applying dynamic braking to a. c. crane motor.**

In the original arrangement the hoist side and the lower side of the controller were the same. By changing the lower side of the controller so that d. c. excitation in place of alternating current could be applied to the stator on contact fingers *5* and *8*, dynamic braking was obtained. Resistance was inserted in the d. c. supply so as to limit the direct-current excitation to about 75 amp. This current is applied across one phase of the stator winding, giving about 12½ volts drop in the winding.

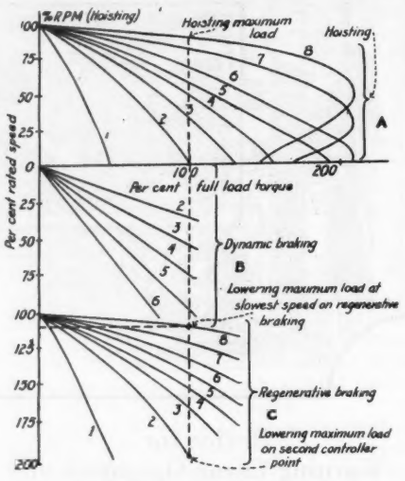



**Fig. 2—Before and after performance of crane motor.**

At *A* are shown the characteristic speed-torque curves of the motor during hoisting. The numbers placed beside each curve are the numbers corresponding to the point of the controller on which the motor gives this performance. With the original controller connections, these curves also applied during lowering, providing the motor drove the light hook down. If the load was sufficient to overhaul the motor, regenerative braking was obtained and lowering was according to the curves shown at *C*, which are for regenerative braking. As can be seen, the slowest lowering speed with maximum load was about 10 per cent above synchronous speed. A speed of 100 per cent above synchronism was attained on the second lowering point of the controller. This was unsatisfactory, so dynamic braking was substituted for regenerative braking during lowering. The characteristic curves for dynamic braking as used on this controller and motor are shown at *B*. This gives accurate control of the motor between 5 and 100 per cent of rated speed when lowering. The seventh and eighth points of lowering did not use dynamic braking but were arranged to give regenerative braking so as to make it possible to drive the hook down in case the load was not sufficient to overhaul the motor.

vertically. Inspection of the curves at *C* will show that the lowest speed obtainable when lowering an overhauling load is with all the resistance cut out, as on the eighth point of the controller. This is shown on curve *8*. The speed at 100 per cent torque on the eighth point is 10 per cent above synchronous speed, as can be seen from the curve. The second point of the controller, as shown by curve *2* at *C*, gives nearly 100 per cent above synchronous speed and the first point gives an even higher speed. The trouble had been caused by the operator trying to lower heavy loads on these points. It was decided that about 128 per cent of synchronous speed was as high as it was desirable to go when lowering the maximum load. In other words, the maximum speed

that was desired should not be higher than the minimum speed that was then obtainable.

It was further decided to use dynamic braking during lowering so as to obtain this result. As shown by the characteristic curves at *C* of Fig. 2, it is theoretically impossible to get less than synchronous speed when lowering any load by means of regenerative braking. Regenerative braking may be defined as braking obtained by operating an induction motor as an induction generator. Since an induction motor must be run above synchronism before it acts as an induction generator, it can be readily seen that no braking action is obtainable below synchronism. On the other hand, dynamic braking consists of obtaining braking action by exciting the fields of a motor with direct current and pumping the generated alternating current through a resistance connected across the motor terminals. In this case the resistance was connected across the slip rings and a controller was required that would operate the motor from the alternating-current supply in the usual way when hoisting the load, but excite the field with direct current when lowering the load. Such a controller is shown in Fig. 1. The controller that had been previously used had a development or arrangement of segments and contact fingers, that was the same on both the hoisting and lowering sides.

The new controller has the same development on the hoist side, but on the lowering side provision is made for applying d. c. excitation to the stator winding on the first to the sixth points, inclusive. In moving the controller from the first to the sixth points when lowering, resistance is cut out of the rotor circuit, thereby causing less dynamic braking and permitting the motor to lower at a greater speed. On the seventh and eighth points, the dynamic braking circuit is broken and the stator of the motor is connected across the line so as to obtain regenerative braking on these points, thus giving the same speed as was formerly obtained with regenerative braking on these two points of the controller.

The advantage of dynamic braking over regenerative braking is seen at a glance by comparing the curves shown at *C* with those at *B* of Fig. 2. As can be seen from the curves shown at *B*, lowering speeds of as low as 5 or 10 per cent of full-load speed can be obtained. In other words, with dynamic braking on points *1*, *2*, *3*, *4*, *5* and *6* of the controller, slower lowering speeds are obtained than are possible with regenerative braking, as shown by the curves at *C*.

Resistance was connected in series with the d. c. excitation so as to apply 75 amp., at 12½ volts across one phase of the stator winding. With this excitation a minimum speed of 42 f.p.m. is obtained on the second point lower of the controller. Successive speeds of 74, 107, 135 and 178 f.p.m., are obtained on points *3*, *4*, *5* and *6*, respectively, of the controller. The final speed obtained on going to points *7* and *8* and using the regenerative action is approximately 200 f.p.m. This arrangement gives a speed slow enough for lowering heavy loads carefully and also, if desired, a speed fast enough for lowering a light hook is obtained by using the seventh and eighth points of the lowering side of the controller. Points *7* and *8* of the lowering side of the controller give regenerative braking if the load overhauls the motor, and if the load does not overhaul the motor, the motor will drive the light hook down.

A mechanical load brake might have been used instead of dynamic braking. With this type of brake, it is necessary for the motor to exert positive torque when lowering a light hook. This method was not considered here because the crane was subjected to continuous heavy service and it was thought that the wear and tear on a mechanical device would give more trouble than either regenerative or dynamic braking, which accomplishes braking with absolutely no mechanical friction and requires no periodical adjustment or replacement of parts.

R. F. EMERSON.
Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

## Current Values Required to Fuse Solid Copper Wire

WHILE the use of copper wire for fuse purposes is to be discouraged just as much as possible, occasions do arise when, due to an emergency or other good reason, it becomes necessary to use it temporarily for this purpose. In the absence of definite information as to the current required to fuse a given size of bare copper wire, it is necessary to guess at the proper size of wire to use and serious errors may be made, as the usual tendency is to select wire that has a current-carrying capacity considerably in excess of the desired value. Various other occasions arise from time to time when a knowledge of the maximum current-carrying capacity of wire of different sizes is very useful.

**Fusing Current of Various Sizes of Copper Wire**

| B. & S. Gage | Amperes | B. & S. Gage | Amperes |
|---|---|---|---|
| 10 | 333 | 18 | 83 |
| 11 | 284 | 19 | 67 |
| 12 | 235 | 20 | 58 |
| 13 | 200 | 21 | 49 |
| 14 | 166 | 22 | 41 |
| 15 | 139 | 23 | 35 |
| 16 | 117 | 24 | 29 |
| 17 | 99 | 25 | 25 |

Tests on wire of the different sizes given indicate that the average current required to fuse them is as shown in the table. These values apply only to bare copper wires. If they are enclosed or covered, the current value required to fuse them will be several per cent lower.

FREDERICK KRUG.
Supt. Power Construction,
Porto Rico Ry., Light & Power Co.,
San Juan, Porto Rico.

## Unusual Combination of Motor and Starter Trouble

WHEN emergency replacements of damaged equipment are made it is well to see that the equipment which is put in is fitted in every respect to the service and to the controlling and other related equipment. Failure to do this may cause delays and expense out of all proportion to the original cause of the trouble. The truth of this is shown by a recent experience.

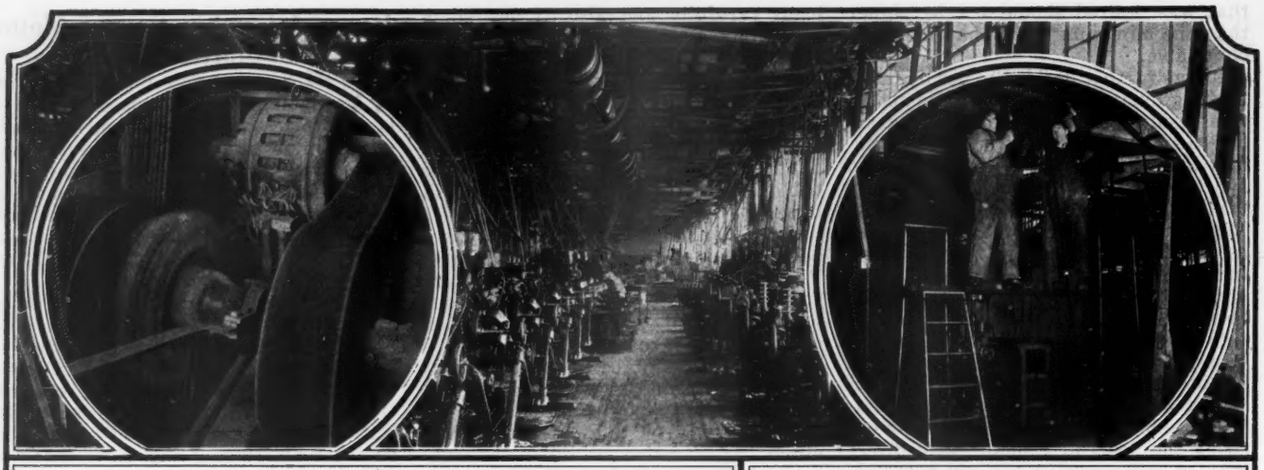
A 3-hp. motor had for some time driven a lineshaft to which were connected several machines including a heavy grindstone, which added little to the load but which had to be started slowly in order to avoid throwing its belt. This condition imposed extra duty on the 3-hp. starter and the resistance coils sometimes burned out. On one of these occasions a 7½-hp. starter was substituted for it, but the motor was not changed.

This starter was of the type that has the no-voltage release coils in series with the motor shunt field winding, and as the coil had too few turns to be strong enough when energized by the smaller current of the 3½-hp. motor, the rheostat handle was tied over with a string. One day voltage left the line and returned before anyone thought to open the line switch. The motor blew up and was replaced with a 15-hp. motor, the 7½-hp. starter being left in place. The no-voltage release coil of this starter was unable to stand the field current of the 15-hp. motor and a coil lead was burned off, thus opening the field circuit while the motor was running. This caused the motor to flash over to ground and blow the fuse.

There was nothing seriously the matter with the motor, which could have been cleaned and put back in operation, although it appeared to be much worse off than it really was. In desperation the electrician installed a 20-hp. motor and starter that happened to be on hand for another purpose. Unfortunately, this motor was compound wound and, as luck would have it, it was connected for the wrong direction of rotation. As there was no room to turn the motor end-for-end, the shunt field connections were reversed in order to reverse the direction of rotation. This placed the shunt and series windings in opposition, which was trouble enough in itself; but to make matters worse, in changing the shunt field connections an armature and field lead became interchanged. The result was that the armature was in series with the no-voltage release coil, while the rheostat resistance was in series with the shunt field winding. The no-voltage release coil burned out at once.

By this time the original 3-hp. motor and starter had been received from the repair shop. After they were installed there was no further trouble. The expense and delays which this series of misfortunes occasioned were far in excess of what they should have been and were considerably increased by the necessity of finding or making pulleys that could be used with motors of different sizes and speeds to give somewhere near the lineshaft speed desired.

Brooklyn, N. Y. J. A. HORTON.



*Mechanical Maintenance of*

# Power Drives

***This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.***

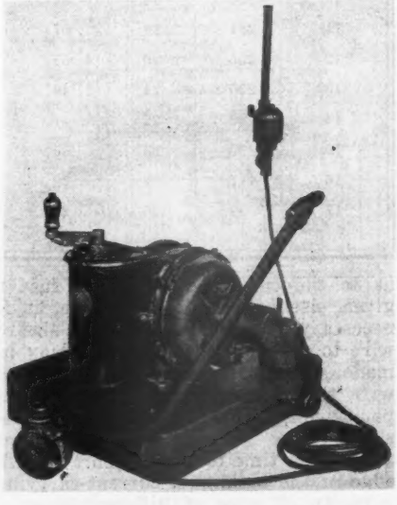
## Special Base Makes Portable Motor Stationary for Temporary Drives

MANUFACTURERS of special machinery and machine tools practically always operate the machine for a short time to see that it works properly before it is packed for shipping. In some cases, the machines are so placed that they may be driven from a lineshaft. On larger machines, however, this is more difficult and the usual practice is to line up a motor so as to drive the machine where it is sitting. One problem that is often troublesome, is in providing a temporary mounting for the motor that will keep it stationary, particularly if small size motors are to be used. The accompanying illustration shows how one company which manufactures a line of special machinery for making baskets, boxes, fibre containers and other similar packages, has solved this problem.

Here the motor with its controller are mounted on a solid cast-iron base weighing 1,800 lb. This is heavy enough to hold the motor against any belt tension. When moved this motor base is supported by two small rear wheels, one of which is shown in the illustration, and the special Howe truck handle manufactured by the Howe Chain Co., Muskegon, Mich. This truck handle, shown attached to the front of the base, is provided with a single wheel and is hooked into a bracket bolted on the front end of the base. Pushing down on the handle elevates the front end from the floor so that the entire motor and its base may be pulled about wherever desired. The rollers on the rear of this base are mounted eccentrically on a shaft. Pulling back on the handle, shown attached to the roller, lowers the base onto the floor.

Whenever a machine is assembled and ready to be tested out one of the three portable motors which are mounted on the bases described above, is placed in line with the machine, belted up and placed flat on the floor by removing the handle and throwing over the eccentric rollers. Power is obtained by plugging into a nearby socket. These sockets are of the Ralco safety type with an extra wire for grounding the frame of the motor.

Two of the three portable motors are of 3-hp. and the other is of 6½-hp. rating. These are General Electric multi-speed motors connected to General Electric drum-type controllers which give speeds of 600, 900, 1,200 and 1,800 r.p.m. The motors operate on 220-volt, three-phase, 60-cycle current. Additional variations of speed may be obtained by using different sizes of pulleys. For example, each motor is fixed so that 6-in., 4½-in. and 3½-in. pulleys can be used interchangeably.



**By means of a portable motor, such as this, all new machines are given a running test.**

The cast-iron base upon which the motor and its controller are mounted weighs 1,800 pounds and is heavy enough to hold the motor firmly in place. The small rollers at the rear of the base are mounted on eccentric shafts, by adjusting which the base can be placed flat on the floor. These motors may be moved by the special handle and wheel at the front. This is removed when the motor is in use.

Saranac Machine Co., Benton Harbor, Mich. L. C. SHEARER.

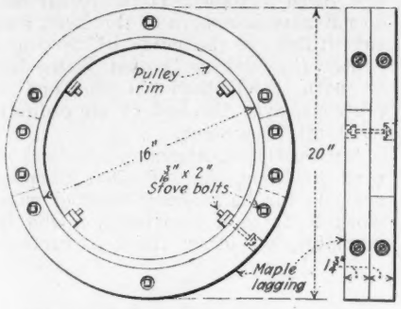
## Quick Method of Lagging Up a Metal Pulley

MASTER mechanics are frequently called upon to build up a pulley to larger size. This may be due to accidents to existing pulleys, rush jobs or specials that require a different speed, distance from a source of supply from which the right size could be obtained if time were given, or possession of a pulley nearly right and the lack of willingness to leave this on the shelf when the desired size can be made by building up.

In a general way, the method of doing such a job is well known but when it comes to giving a workman instructions, he asks for definite sizes. The following is given to offer an example of good practice. There are two ways of doing this work. One way is to place a series of blocks crosswise of the pulley face. This requires a number of small pieces. The other method is to cut annular pieces which fit on the curve of the pulley. This requires only a few pieces according to the thickness and width of the lumber at hand and the face of the pulley. I consider the latter to be the preferable method.

As shown by the drawing, only four pieces were required to lag this 16-in. pulley up to 20 in. in diameter and wide enough for a 3-in. belt. With pulleys of about this size this can be done when 10-in. to 12-in. planks are available to cut from. Maple or cherry make the best job, but oak or gum can be used if maple is not at hand. Ordinarily 2-in. rough lumber will dress to the thickness required here; in fact, it could be left as 2-in. stock without dressing should the occasion require it because the mating surfaces

are drawn tightly together. In this case only one size of bolt ($\frac{3}{4}$-in. by 2-in.) is used. Bolts are double nutted where convenient to get at, to make the nuts less likely to loosen. The heads are countersunk deeply and present a safe working face. After bolting on the pieces, the pulley is turned in a lathe. It will be noticed that there is a through bolt on each side of every joint and that the joints are staggered.




**When emergencies require temporary speed changes wood lagging, as shown here, may be built up quickly without permanent damage to pulley.**

## Working Up Discarded Belts for Small Machine Drives

AN Eastern machine shop works up discarded double leather belts in an interesting way. This shop has four long 8-in. discarded main belts that have supplied it with belt material for several years, although each of the individual belts had previously given from 20 years' service up. These belts are split and the single belts thus produced are used in the manufacturing department, where dozens of milling machines and drills use light belts, such as feed belts and spindle driving belts, of short length. On the drills, the typical drive is an open belt 1⅛ in. to 2 in. wide, on about 20-in. centers, and operating at high speed over rather small pulleys. Such work demands a flexible belt of considerable durability and chrome leather belts, made endless at the factory, had been used.

The plan of using one ply of the old belts did away with expenditures of this sort. With a piece of the old belt and a can of cement, one of the repair gang makes up these belts in his odd moments and they serve the purpose well.

The old double belts had been well taken care of during their life and were thoroughly run in. They had been removed because of the separation of the plies and the disintegration which followed. The men in this plant have found that they can get a lot of small belts out of the good pieces from a 50-ft., 8-in., double belt.

Another interesting point was noted in this same shop where several milling machines are rigged up with rotary fixture tables which, of course, revolve slowly. The designer of these fixtures kept the old double belts in mind when he laid out their drive. The shafts driving these rotaries are run at 10 r.p.m.; ordinarily when a practical man gets down to 10 r.p.m. on small fixtures and has considerable power to transmit, he goes to gears or chains. This man, however, put a 9-in. pulley on his 10-r.p.m. shaft and drove it on 12-in. centers from a 2½-in. pulley on a machine shaft that had ample power in it. Contrary to the usual conception of such a "freak" drive, this one does not slip and the belt is not stretched to the breaking point. A 3-in. belt cut from this same old drive belt does the work and the way it walks through the cut is a pleasure as well as a revelation; it is so soft and flexible that every fiber is pulling and clinging to the pulleys.

These drives cost practically nothing because the old belt and old pulleys were on hand, but for all practical purposes they are operating 100 per cent efficient.

## Mounting a Motor with a Belt Guard to Give Headroom

MANY buildings that are used for industrial purposes were never designed for such service. To get power, light, ventilation, and transportation in such places has brought out a wealth of engineering and architectural genius from many practical shop men. For example, in one plant it was decided to do some manufacturing in a room that had formerly been used as a storeroom.

A layout of the proposed machine arrangement and a survey of the rooom showed that a line of shafting would have to be put in near one side of the room, and that the driving motor would have to be mounted on the other side, either on the floor or placed higher up on the wall or ceiling. The objection to this was that a factory trucking route through the center of the room could not be changed. This trucking aisle would also become the main aisle for the manufacturing operations.

To place the motor on the floor would require an inclined belt drive that would cut off the aisle entirely, and so could not be considered. There remained the alternative of hanging the motor from the ceiling or of placing it on a bracket that would put it at the same height. Either method would raise the lower side of the belt so that it would not interfere with the use of the aisle.

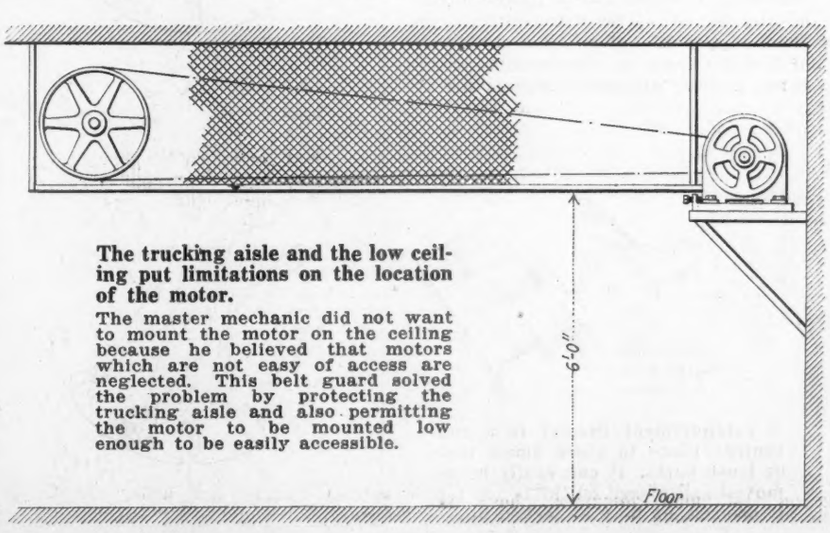
The master mechanic strongly objected because he believed that if a motor is placed at the ceiling, it is sure to be neglected. It is so high up that the oiler cannot get his head above it to see in the oil wells, and is bumping himself while working around it. He believed that a motor should be placed so that it is "get-at-able" and can receive personal attention, or it will not get cleaned or oiled or inspected as would a motor that is within reach. His solution of this problem is shown by the accompanying drawing.

A platform was erected along the side wall and the motor base bolted to it. This brought the motor about 2 ft. down from the ceiling and automatically removed the objections of the master mechanic. The lower run of the belt was then horizontal and about 6½ ft. from the floor. This was high enough to clear the head, but it would not have been good practice to allow a fast-running belt so close to a passageway, nor would it have passed safety inspection. A guard was imperative and was placed around the belt as shown.

The low belt, when guarded, permitted freer operation than would have been the case with a belt left unguarded and placed a little higher. The under side of the guard was a little over 6 ft. high and tightly boarded so that no person of ordinary height would bump into it. Also, tight mesh sides were added so that there would be no danger even if a stray piece on a truck projected above that height, or if a hand were raised to signal. Traffic and manufacturing operations could be pursued, freely.

A further advantage besides those already mentioned, was found in having the motor low down: A man could give it all necessary attention while standing comfortably on a low box. The motor was out of the way, yet accessible without lugging a ladder around. Its bearings could be felt with the hand, by standing on tiptoe.

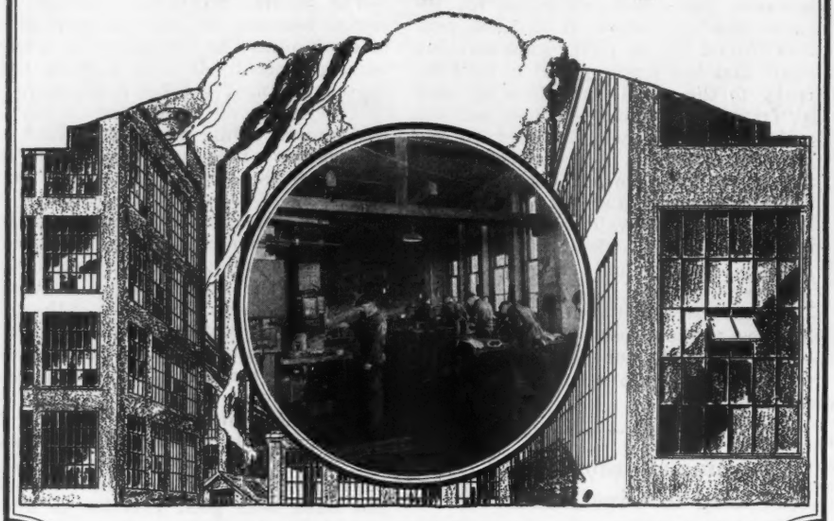
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.




**The trucking aisle and the low ceiling put limitations on the location of the motor.**

The master mechanic did not want to mount the motor on the ceiling because he believed that motors which are not easy of access are neglected. This belt guard solved the problem by protecting the trucking aisle and also permitting the motor to be mounted low enough to be easily accessible.

# In the Repair Shop



*This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.*

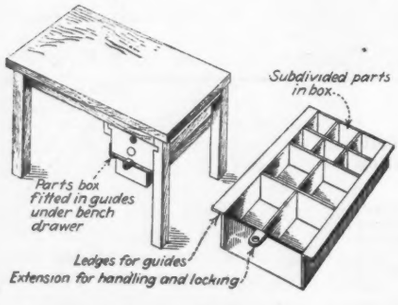
## Attaching Divided Compartments to Tool Drawer

ALTHOUGH the common method of keeping separate small screws, nuts, washers, lock washers, cotter pins and other small parts varying in size, is to use small pans, divided into sections, there are times when it is desirable to have such a compartment for small parts either in or attached to a tool drawer where they may be locked up. How this was done in one shop is shown in the accompanying sketch.

A box was divided into small compartments and provided with drawer ledges as shown. The front edge of the compartment drawer is also fitted with a small extension on the front which has two uses. The drawer ledge slips in the guide and so fits snugly under the bench drawer. In this way compartment drawers can be stored away on the bottom of the bench drawer when not in service or easily removed, if desired, to be placed on top of the bench. The extension on the front of the drawer in connection with a similar piece on the bottom of the bench drawer provides a means for attaching a padlock if it is desired to lock it up. The extension also makes it easier to remove and handle the box.

A locked storage box such as this may be provided at only a small additional expense and is easily attached to the regular bench drawer. If this attachment is made rather close fitting, there is no danger of losing any of the small pieces or tools.

Washington, D. C. G. A. LUERS.


Subdivided parts in box
Parts box fitted in guides under bench drawer
Ledges for guides
Extension for handling and locking

**A compartment drawer is a convenient place to store small tools or loose parts. It can easily be removed and placed on the bench top, if desired, or may be locked up.**

## Rubber Head on Hammer for Use on Finished Surfaces

OCCASIONALLY, in repair work, particularly when hammering out dents in finished or enameled sheet metal, it is desirable to have an extra-soft faced hammer. If the repair men do not have hammers of this sort, good substitutes can be made by forcing a rubber tip, such as is used on the legs of bath stools and on the end of crutches, over the end of an ordinary machinist's hammer.

Rubber-tipped hammers also may be used for a number of other purposes such as for hammering finished woodwork to force it into position and for pounding on other finished surfaces.

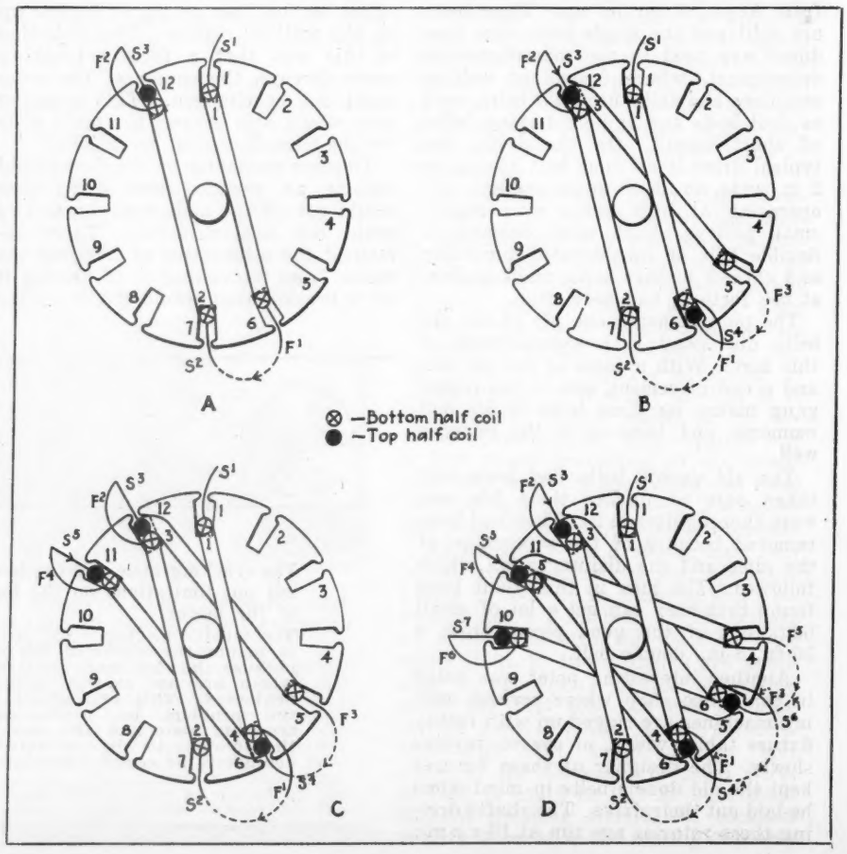
## Laying in a Chorded Split-Loop Winding

THE accompanying diagrams and tables give a very easy method of laying out and winding chorded split-loop windings.

Let us first examine the method of laying in the winding. The start of the winding is at $S^1$ in diagram *A* of Fig. 1. The first coil is wound in slots *1* and *6* and ends at $F^1$ in the bottom of slot *6*. $F^1$ is connected to $S^2$, the start of the

**Fig. 1.—Steps in winding a chorded split-loop winding.**

At *A* is shown the first parallel pair of coils placed in the armature slots. The location of the third coil is shown in *B*. *C* shows the fourth coil wound in. The third and fourth coils constitute the second parallel pair of coils. In *D* the fifth and sixth coils have been wound in.



second coil. This coil is wound in slots *7* and *12*, and ends at $F^2$ which is connected to $S^3$, the start of the third coil.

Diagram *B* of Fig. 1 shows the third coil wound in and the start of the fourth coil, $S^4$ in the top of slot *6*. In diagram *C*, the fourth coil has been completed and the fifth coil started at the top of slot *11*. Diagram *D* shows the manner of laying in the fifth and sixth coils.. Fig. 2 shows the complete winding diagram, with the winding starting at the bottom of slot *1* with lead $S^1$ and finishing at the top of slot *7* with lead $F^{12}$.

It will be noticed that the coils are laid in in parallel pairs. For instance, coils *1* and *2* are parallel to each other as shown in diagram *A* of Fig. 1; likewise coils *3* and *4*, in diagram *C*.

After the first two coils are put in, it will be noticed that the slots are filled up as the winding progresses and that most of the top leads are brought out on top of the coil. This makes it easy to put them down and make a nice looking job when finished.

After once becoming familiar with this type of winding, a winding diagram such as shown in Figs. 1 and 2 is not needed. The accompanying table gives all data that the winder needs.

As an example of the use of the table let us lay out a winding for the armature shown in Figs. 1 and 2. Since this armature has 12 slots, we refer to the 12-slot column of the table and find that the winding has 12 coils wound in six parallel pairs. Reading down this column we find the number of the slot for the start and finish of each coil. It is interesting to note that with this type of winding, the last coil will always start in slot *2*.

Wilkinsburg, Pa. A. C. ROE.

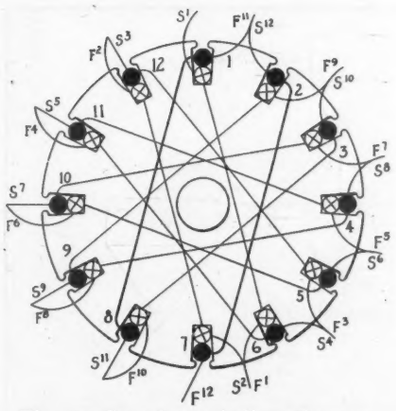



**Fig. 2—Complete winding diagram for a chorded split-loop winding.** In this diagram the top half-coils are represented by black dots, while the circles with crosses in them indicate the location of the bottom half-coils. $S^1$ is the start of the first coil, $F^1$ is the finish of the first coil. $S^2$ is the start of the second coil and so on through the winding.

## Banding a Large Armature Under Difficulties

THAT necessity is the mother of invention, is frequently demonstrated in the small motor repair shop, where the armature winder is often confronted with a serious lack of equipment. It is here that "Mother Necessity" often calls the workman's inventive powers into action.

Recently in a small shop it happened that a large armature ready for banding was found to be much too large for the only lathe in the shop. By the following method no time was lost in overcoming this difficulty.

The armature was placed on two stout horses directly in front of the lathe, the commutator lined up with the chuck and the horses blocked top and bottom to prevent slipping. After padding the commutator with canvas to prevent damage, a belt was run over the chuck of the lathe and the commutator of the armature to be banded. This makeshift took but a few minutes to erect and proved satisfactory. MAURICE M. CLEMENT.

Long Beach, Calif.

## Starting and Finishing Slots for Each Coil of a Chorded Split-Loop Winding

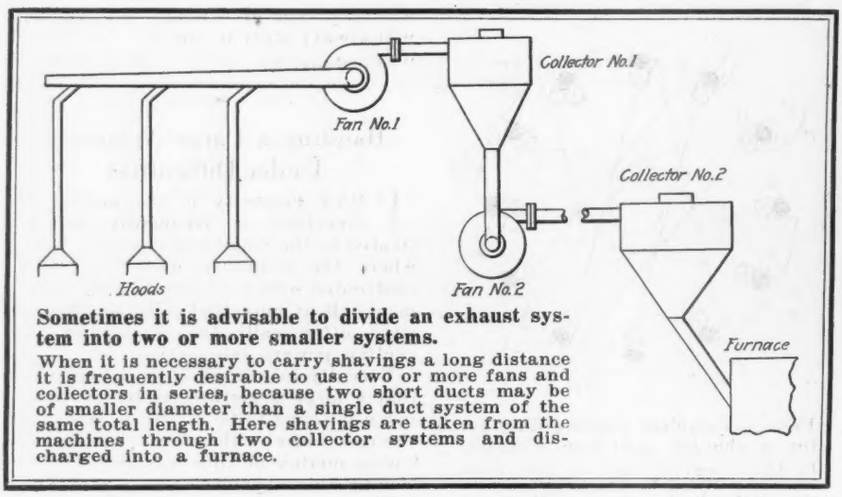
| Coil No. | 10 Slots | | 12 Slots | | 14 Slots | | 16 Slots | | 18 Slots | | 20 Slots | | 22 Slots | | 24 Slots | | 26 Slots | | 28 Slots | | 30 Slots | | 32 Slots | | 34 Slots | | 36 Slots | | Coil No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | Start | Finish | |
| 1 | 1 | 5 | 1 | 6 | 1 | 7 | 1 | 8 | 1 | 9 | 1 | 10 | 1 | 11 | 1 | 12 | 1 | 13 | 1 | 14 | 1 | 15 | 1 | 16 | 1 | 17 | 1 | 18 | 1 |
| 2 | 6 | 10 | 7 | 12 | 8 | 14 | 9 | 16 | 10 | 18 | 11 | 20 | 12 | 22 | 13 | 24 | 14 | 26 | 15 | 28 | 16 | 30 | 17 | 32 | 18 | 34 | 19 | 36 | 2 |
| 3 | 10 | 4 | 12 | 5 | 14 | 6 | 16 | 7 | 18 | 8 | 20 | 9 | 22 | 10 | 24 | 11 | 26 | 12 | 28 | 13 | 30 | 14 | 32 | 15 | 34 | 16 | 36 | 17 | 3 |
| 4 | 5 | 9 | 6 | 11 | 7 | 13 | 8 | 15 | 9 | 17 | 10 | 19 | 11 | 21 | 12 | 23 | 13 | 25 | 14 | 27 | 15 | 29 | 16 | 31 | 17 | 33 | 18 | 35 | 4 |
| 5 | 9 | 3 | 11 | 4 | 13 | 5 | 15 | 6 | 17 | 7 | 19 | 8 | 21 | 9 | 23 | 10 | 25 | 11 | 27 | 12 | 29 | 13 | 31 | 14 | 33 | 15 | 35 | 16 | 5 |
| 6 | 4 | 8 | 5 | 10 | 6 | 12 | 7 | 14 | 8 | 16 | 9 | 18 | 10 | 20 | 11 | 22 | 12 | 24 | 13 | 26 | 14 | 28 | 15 | 30 | 16 | 32 | 17 | 34 | 6 |
| 7 | 8 | 2 | 10 | 3 | 12 | 4 | 14 | 5 | 16 | 6 | 18 | 7 | 20 | 8 | 22 | 9 | 24 | 10 | 26 | 11 | 28 | 12 | 30 | 13 | 32 | 14 | 34 | 15 | 7 |
| 8 | 3 | 7 | 4 | 9 | 5 | 11 | 6 | 13 | 7 | 15 | 8 | 17 | 9 | 19 | 10 | 21 | 11 | 23 | 12 | 25 | 13 | 27 | 14 | 29 | 15 | 31 | 16 | 33 | 8 |
| 9 | 7 | 1 | 9 | 2 | 11 | 3 | 13 | 4 | 15 | 5 | 17 | 6 | 19 | 7 | 21 | 8 | 23 | 9 | 25 | 10 | 27 | 11 | 29 | 12 | 31 | 13 | 33 | 14 | 9 |
| 10 | 2 | 6 | 3 | 8 | 4 | 10 | 5 | 12 | 6 | 14 | 7 | 16 | 8 | 18 | 9 | 20 | 10 | 22 | 11 | 24 | 12 | 26 | 13 | 28 | 14 | 30 | 15 | 32 | 10 |
| 11 | | | 8 | 1 | 10 | 2 | 12 | 3 | 14 | 4 | 16 | 5 | 18 | 6 | 20 | 7 | 22 | 8 | 24 | 9 | 26 | 10 | 28 | 11 | 30 | 12 | 32 | 13 | 11 |
| 12 | | | 2 | 7 | 3 | 9 | 4 | 11 | 5 | 13 | 6 | 15 | 7 | 17 | 8 | 19 | 9 | 21 | 10 | 23 | 11 | 25 | 12 | 27 | 13 | 29 | 14 | 31 | 12 |
| 13 | | | | | 9 | 1 | 11 | 2 | 13 | 3 | 15 | 4 | 17 | 5 | 19 | 6 | 21 | 7 | 23 | 8 | 25 | 9 | 27 | 10 | 29 | 11 | 31 | 12 | 13 |
| 14 | | | | | 2 | 8 | 3 | 10 | 4 | 12 | 5 | 14 | 6 | 16 | 7 | 18 | 8 | 20 | 9 | 22 | 10 | 24 | 11 | 26 | 12 | 28 | 13 | 30 | 14 |
| 15 | | | | | | | 10 | 1 | 12 | 2 | 14 | 3 | 16 | 4 | 18 | 5 | 20 | 6 | 22 | 7 | 24 | 8 | 26 | 9 | 28 | 10 | 30 | 11 | 15 |
| 16 | | | | | | | 2 | 9 | 3 | 11 | 4 | 13 | 5 | 15 | 6 | 17 | 7 | 19 | 8 | 21 | 9 | 23 | 10 | 25 | 11 | 27 | 12 | 29 | 16 |
| 17 | | | | | | | | | 11 | 1 | 13 | 2 | 15 | 3 | 17 | 4 | 19 | 5 | 21 | 6 | 23 | 7 | 25 | 8 | 27 | 9 | 29 | 10 | 17 |
| 18 | | | | | | | | | 2 | 10 | 3 | 12 | 4 | 14 | 5 | 16 | 6 | 18 | 7 | 20 | 8 | 22 | 9 | 24 | 10 | 26 | 11 | 28 | 18 |
| 19 | | | | | | | | | | | 12 | 1 | 14 | 2 | 16 | 3 | 18 | 4 | 20 | 5 | 22 | 6 | 24 | 7 | 26 | 8 | 28 | 9 | 19 |
| 20 | | | | | | | | | | | 2 | 11 | 3 | 13 | 4 | 15 | 5 | 17 | 6 | 19 | 7 | 21 | 8 | 23 | 9 | 25 | 10 | 27 | 20 |
| 21 | | | | | | | | | | | | | 13 | 1 | 15 | 2 | 17 | 3 | 19 | 4 | 21 | 5 | 23 | 6 | 25 | 7 | 27 | 8 | 21 |
| 22 | | | | | | | | | | | | | 2 | 12 | 3 | 14 | 4 | 16 | 5 | 18 | 6 | 20 | 7 | 22 | 8 | 24 | 9 | 26 | 22 |
| 23 | | | | | | | | | | | | | | | 14 | 1 | 16 | 2 | 18 | 3 | 20 | 4 | 22 | 5 | 24 | 6 | 26 | 7 | 23 |
| 24 | | | | | | | | | | | | | | | 2 | 13 | 3 | 15 | 4 | 17 | 5 | 19 | 6 | 21 | 7 | 23 | 8 | 25 | 24 |
| 25 | | | | | | | | | | | | | | | | | 15 | 1 | 17 | 2 | 19 | 3 | 21 | 4 | 23 | 5 | 25 | 6 | 25 |
| 26 | | | | | | | | | | | | | | | | | 2 | 14 | 3 | 16 | 4 | 18 | 5 | 20 | 6 | 22 | 7 | 24 | 26 |
| 27 | | | | | | | | | | | | | | | | | | | 16 | 1 | 18 | 2 | 20 | 3 | 22 | 4 | 24 | 5 | 27 |
| 28 | | | | | | | | | | | | | | | | | | | 2 | 15 | 3 | 17 | 4 | 19 | 5 | 21 | 6 | 23 | 28 |
| 29 | | | | | | | | | | | | | | | | | | | | | 17 | 1 | 19 | 2 | 21 | 3 | 23 | 4 | 29 |
| 30 | | | | | | | | | | | | | | | | | | | | | 2 | 16 | 3 | 18 | 4 | 20 | 5 | 22 | 30 |
| 31 | | | | | | | | | | | | | | | | | | | | | | | 18 | 1 | 20 | 2 | 22 | 3 | 31 |
| 32 | | | | | | | | | | | | | | | | | | | | | | | 2 | 17 | 3 | 19 | 4 | 21 | 32 |
| 33 | | | | | | | | | | | | | | | | | | | | | | | | | 19 | 1 | 21 | 2 | 33 |
| 34 | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 18 | 3 | 20 | 34 |
| 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | 20 | 1 | 35 |
| 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 19 | 36 |

In each column, one line is marked "Start" and the other "Finish." This refers to the number of the slot in which the coil starts and to the number of the slot in which the coil finishes.

The first line in each column gives the winding pitch.

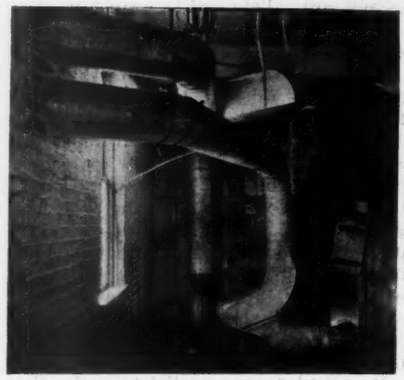
The parallel pairs of coils for a winding having a given number of slots are enclosed in the horizontal lines in the column labelled with the given number of slots.

Note that with this type of winding, the last coil of the winding always starts in slot 2.




**Sometimes it is advisable to divide an exhaust system into two or more smaller systems.**

When it is necessary to carry shavings a long distance it is frequently desirable to use two or more fans and collectors in series, because two short ducts may be of smaller diameter than a single duct system of the same total length. Here shavings are taken from the machines through two collector systems and discharged into a furnace.



**The intake of the pneumatic handling system at the Charlottesville Woolen Mills.**

This pneumatic collecting and conveying system handles wool to and from various parts of the plant as well as the refuse from wool and woolen waste. By shifting the damper in the intake pipe on the floor, material may be removed from the room back of the fan or from another room through the suction pipe which goes up through the wall. Similarly the material is discharged wherever desired through various duct outlets.

# Handling Materials by Air

*(Continued from page 431.)*

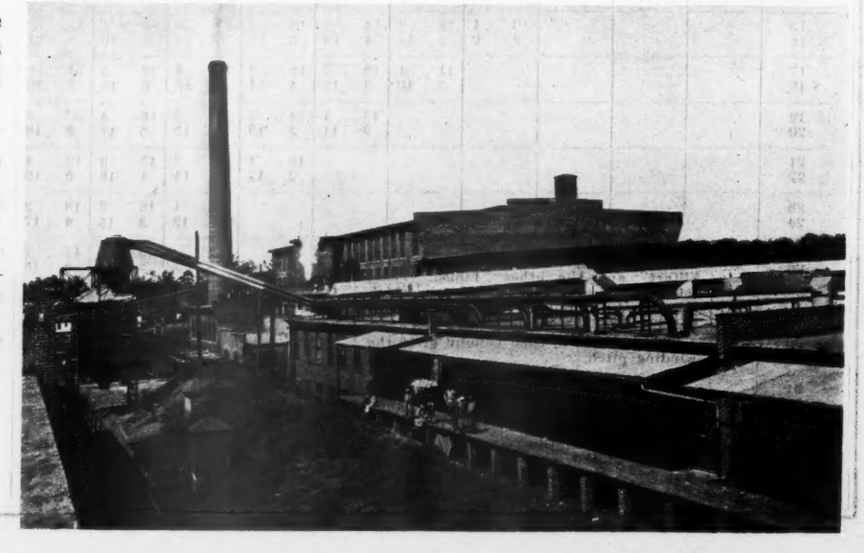
used to handle shavings except that special fans are required with vanes which will not catch stringy material, as in this type of conveying the material passes through the fan. The advantage of this is that the material is kept clean and can be moved quickly and economically. In some cases, particularly where the material does not contain dust, the storage rooms serve as a separator.

The other two methods of pneumatic conveying are generally used in connection with materials or products which have more or less powdered or pulverized material in them. One of these is known as the vacuum system and the other as the pressure system of pneumatic conveying. The vacuum system consists of a pipe or hose, the end of which is inserted into the loose material to be moved, a conveying pipe, a separating system and an exhauster. The arrangement of these varies somewhat to fit the problems of the installation and the material handled.

In general, practically any heavy material is taken out of the line ahead of the exhauster. In some cases a filter is placed back of the exhauster to remove any fine dust before it is discharged into the atmosphere. More frequently, some form of filter is placed in the line just after the separator so that all dust is removed before entering the exhauster. The inlet to this separator consists of a long pipe with several branches so that connections may be taken off for unloading at different locations. Such a system is very frequently used for unloading cars into storage and also for moving from storage to other places in the plant. Some of the various types of filters and separators which may be used in connection with a pneumatic conveying system were described in the article entitled, "Separating Dust from Air in Industrial Plants," which appeared in the August issue of INDUSTRIAL ENGINEER.

The capacity of such a system varies according to the distance handled, the material, and the diameter of the intake line. Material can be handled vertically as well as horizontally and the pipe lines may be located anywhere out of the way. Such equipment is commonly used for unloading materials from cars and boats. In one case a conveyor line over 400 ft. long, which handles acetate of lime in a 2½-in. pipe, conveys about 2½ tons an hour. About 19 hp. is required to operate the vacuum pump. This material varies from lumps the size of a bean down to fine material and weighs about 30 lb. per cu. ft. In another case an aluminum company handles about 20 tons of bauxite per hour from the car to the separator which discharges into the storage tank, a total distance of about 142 ft. which includes a vertical lift of 72 ft. This material is extremely fine and weighs about 65 lb. per cu. ft. Two 3-in. hose lines are used and about 75 hp. is required to operate the equipment.

The pressure system of pneumatic conveying operates at either high or



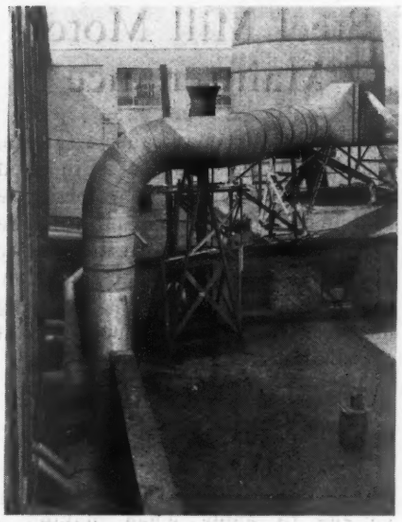
**Cotton may be handled pneumatically at a very low cost.**

This illustration shows a part of the duct work and the cyclone collectors at the Valley Waste Mills, La Grange, Ga., which collect and convey the refuse from the willowing machines.

low pressure. In the low-pressure system the blast is produced by a fan while in the other high-pressure blowers are used. With the low-pressure systems from 50 to 100 cu. ft. of air are required for every pound of material conveyed, depending upon the weight and nature of the material, conveying distance, and so on. Under the high-pressure system from 2 to 10 cu. ft. of air are used for the same purpose.

With the low-pressure pneumatic conveying system the velocity of air used may vary from a few hundred to 5,000 or 6,000 ft. per min. However, under the high-pressure system the velocity ranges from 3,000 to 20,000 ft. per min. Under either type of pressure system some means are used to feed the material into the pipe lines which at the same time does not permit the escape of the air and the lowering of the pressure. Generally the material is fed into the blast line through a specially-built ejector.

The blast in a low-pressure system is produced by a standard fan and material is collected in a metal centrifugal separator. When the volume of air handled and the pressure are comparatively low, galvanized or sheet-iron pipes are used for the ducts. On the high-pressure system the pipe diameter is small and the pipe is more substantial and may be placed in any position. In some cases, owing to the small volume of air handled under the high-pressure system, the material, if it contains only a small amount of dust, can be blown directly into the storge bin where most of it settles down. The air in the storage bin can then be pulled through a filter and the dust separated if necessary. In most cases the material goes through a separator which removes all of the coarse and some of the fine material; the fine dust is then removed as the air passes through a filter. The clean air is then drawn out through an exhauster.



**The fan and collector system at the American Seating Co., Grand Rapids, Mich.**

Here two large exhausters are installed in the center of the collection system and discharge into a dust separator. Each of these systems is made up of several smaller inlets which discharge into them.

There is still another type of pneumatic conveying which is commonly known as a pneumatic tube system. While these were originally installed in department stores for carrying cash to a central cashier's office and the change back to the purchaser, they have lately been installed in many industrial plants to carry production orders, or blueprints, or other information between departments and factory offices, and in some cases to carry small tools. In these systems use is made of a cartridge which fits snugly into a tube and is drawn along by withdrawing the air in front of it or pushed along by air pressure applied behind it.

In plants generating their own power by steam, the handling of ashes enters largely into the problem of waste disposal, in those cases where coal is the fuel employed.

While this is not strictly within the scope of the present article, it should be mentioned briefly, especially in connection with pneumatic conveyors. Ashes are handled by manual labor in wheelbarrows and cars of various kinds, and also by various types of mechanical conveyors, as well as current conveyors which include the hydraulic, vacuum, and steam-jet types of conveyor.

Only the last two will be considered in the present case, as these alone make use of principles already described. The vacuum conveyor consists of an air-tight storage tank, with a turbine or motor-driven centrifugal exhauster for maintaining a partial vacuum. From the tank a pipe line extends to the pits or furnaces from which the ashes are to be removed. This line is provided with intake fittings at the proper points, which can be tightly closed when not in use.

An air intake is essential at the extreme end of the line to maintain the necessary current when the ash intake opening is practically closed by the ashes being fed through it. In order to remove the fine dust from the air passing from the tank to the exhauster it is necessary to install some form of washer between these points.

The steam jet conveyor consists primarily of a line of pipe into which ashes are fed, and through which they are carried to a discharge point by a current of air similar to that in the vacuum system. In this case, however, the suction is produced by the aspirating effect of a steam jet placed just beyond the last intake opening on the storage tank side. The line from this point back to the air inlet at the end is called the suction line and that portion between the steam jet and stor-

**Handling waste paper by air in a paper mill.**

This shows pneumatic conveyor outlets for handling waste paper at the Michigan Paper Co., Plainwell, Mich. The paper is brought from the sorting room and discharged at various places in the room by means of regulating dampers.

age tank, the discharge line. Ashes in the first portion are moved by suction, and in the second portion are driven by the force of the steam jet.

No attempt will be made to compare the advantages and disadvantages of these two systems or to go into details of construction. The advantages of both as compared with mechanical conveyors of various types are their flexibility and ease of installation, as it is possible to reach almost any point and to move the ashes in any direction by the same equipment. Another important point is the matter of cleanliness, which has a strong bearing on industrial establishments where dust and dirt must be avoided. Also, any gases which may be given off are sucked into the pipe and so removed.

Handling materials by means of air has many advantages. Among the most important of these are: the flexibility of the system, the automatic removal of dust and fumes while handling, the small amount of moving parts and power used, and the economy which results largely from the small amount of labor required in connection with the operation. Industrial plants which have a problem in connection with handling any light material, particularly materials which give off dust, will find it worth while to investigate how air might be used to advantage.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and other articles which have appeared in this series: The Air Conditioning & Engineering Co., St. Louis, Mo.; Allen & Billmyre Co., Inc., New York City; American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; E. B. Badger & Sons Co., Boston, Mass.; Bentz Engineering Corp., Newark, N. J;; Buffalo Forge Co., Buffalo, N. Y.; Carrier Air Conditioning Co. of America, Buffalo, N. Y.; Carrier Engineering Corp., Newark, N. J.; The Clarage Fan Co., Kalamazoo, Mich.; The Cooling Tower Co., Inc., New York City; The Dust Recovering & Conveying Co., Cleveland, Ohio; Globe Ventilator Co., Troy, N. Y.; Green Equipment Corp., Chicago, Ill.; Holly Pneumatic Systems, Inc., New York City; Ilg Electric Ventilating Co., Chicago, Ill.; The MacLeod Co., Cincinnati, Ohio; The Martindale Electric Co., Cleveland, Ohio; Mellish-Hayward Co., Chicago, Ill.; Midwest Air Filters, Inc., New York City; D. J. Murray Mfg. Co., Wausau, Wis.; The Northern Blower Co., Cleveland, Ohio; Research Corp., Chicago, Ill.; Reed Air Filter Co., Inc., Louisville, Ky.; P. H. & F. M. Roots Co., Connersville, Ind.; Spray Engineering Co., Boston, Mass.; B. F. Sturtevant Co., Boston, Mass.; Standard Conveyor Co., N. St. Paul, Minn.; The Temco Electric Motor Co., Leipsic, Ohio.

# Steel Mill Motor Maintenance

*(Continued from page 426)*

presence of dirt may cause a failure, even when the machine is in good condition. While it is unfortunate that insulation must be subjected to the danger of breakdown in order to find out if it is in proper condition, this should not deter the operating engineer from making such tests at reasonably frequent intervals.

### VOLTAGE THAT SHOULD BE USED FOR HIGH-POTENTIAL TEST

There is a variety of opinions as to the best percentage of operating voltage to apply when making a high-potential test. The double voltage applied when the apparatus is new is presumably a larger margin of safety than is reasonable after the apparatus has been in service for a period of years. It is the writer's opinion that 150 per cent of normal voltage is the minimum to which the insulation should be allowed to deteriorate. If the insulation will break down on the application of 150 per cent of normal voltage, the apparatus should be rewound or some other radical steps taken.

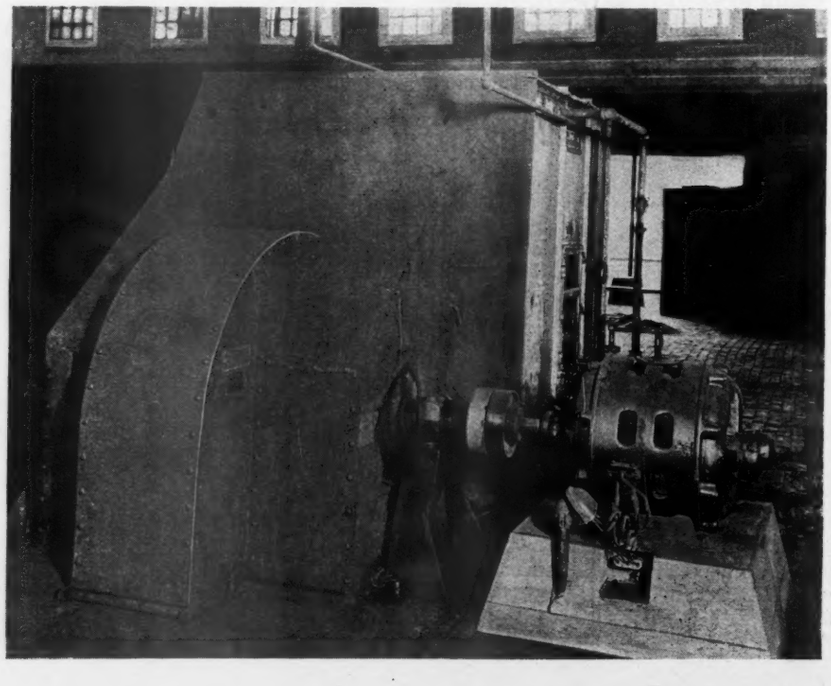
High-potential tests should be made with caution. The machine should be thoroughly cleaned. The insulation must be dry and show a good resistance value. When making tests the testing terminals should be placed on the machine while the circuit is dead and the high voltage applied by closing the low-voltage circuit breaker. When the test is completed the high voltage should be removed by opening the low-voltage circuit first and then removing the test leads.

The severity of the test depends to a marked degree upon the time the test voltage is applied. The writer would suggest that this test be applied for a period not longer than one minute.

At regular intervals steel mill motors and electrical apparatus should be thoroughly overhauled both mechanically and electrically. The mechanical overhauling should include the tightening of all bolts and nuts, attention to bearings, shafts, couplings, alignment, balance, air gaps, and the like. The electrical overhauling should give attention to all connections, commutators, slip rings, insulation, etc. This should be done at least once a year. The insulating varnish mentioned above can be applied at this time and a high potential test may be applied to the insulation. Local conditions will dictate the time of year when a unit can best be spared for a long enough period to make the test or to make repairs in case of a breakdown which might occur as a result of the test.

To sum up the situation, large steel mill motors generally do not show signs of distress until the

**Here is the air washer and blower installation used for supplying clean air to the hot sheet mill motor shown in the illustration on page 423.**



trouble has manifested itself in an actual breakdown. It is therefore essential to exercise considerable vigilance and maintain the motors in good condition if the user is to enjoy a maximum of service with a minimum of maintenance expense and delay in operation.

A section devoted to the question of drying out machines may properly come within the scope of this article. Machines may become wet due to some accident and they frequently are wet during the period of installation and before they are first placed in operation. If the machines become wet at any time they should be thoroughly dried out before being again placed in service. This can be done by applying heat externally or by circulating current in the windings. Drying out by applying heat externally can be done by placing resistance grids under the machine to dissipate roughly about one kilowatt per 100-hp. rating of the machine. Care should be taken that no part of the hot grids comes in contact with the windings. The machines should be covered with a tarpaulin and an opening provided at the top to allow the escape of the moisture, otherwise, it will condense on the machine again as soon as the heat is discontinued. A thermometer should be kept on the machine and the temperature not allowed to exceed 100 deg. C. unless it is known positively that the insulation is of such a nature that higher temperatures will not be injurious.

The time required to dry out a machine thoroughly will vary from a few days to several weeks depending on the size of the machine and the condition of the insulation when starting. Insulation resistance should be determined two or three times a day at uniform intervals during the period of drying out. A curve should be plotted using resistance as ordinates and hours as abscissae. Methods of taking insulation resistance have been described earlier in this article.

Machines that have been dried out by applying external heat only may show a very good value of insulation resistance with a megger and still have moisture in the insulation next to the conductors. This is particularly true of high-voltage machines where the insulation is heavy and it is very difficult to entirely dry out the moisture. Hence a much more effective method is to apply the heat internally by circulating currents. Machines of 2,200 volts or higher can generally be dried by applying 220 volts alternating current simply by connecting this circuit to the terminals without interposing resistance. The machines can be watched very closely at first by observing thermometers placed on the coils to make sure that they do not overheat. The application of current directly to the coils presupposes that the insulation is in good enough condition to withstand this low voltage. If the insulation is in poor condition, external heat should be used until it is safe to apply a low voltage for circulating currents. The same process of taking readings of insulation resistance should be followed as has been described for external heating, until the insulation resistance reaches a fixed value.

The American Institute of Electrical Engineers recommendation for insulation resistance is: Megohms = Voltage ÷ (Kva. + 1,000). This value seems to be low and for some mill apparatus, particularly 2,200-volt machines, the machines should show at least one megohm per 1,000 volts. These values are not given with the understanding that the drying-out process should be stopped when these values are reached, but in every case, the process should be continued until a constant value is obtained. If this constant value does not equal that given above, the manufacturer of the apparatus should be notified.

# Problems of Steel Mill Operation

*(Continued from page 414.)*

More attention is being paid to the remainder of the switching equipment. One operator told of using an interlocking system on his disconnects whereby it was impossible to unlock the enclosures around the disconnects until the oil switch had been opened. At another installation in the Pittsburgh district the disconnects are gang operated. The switchboard operator opens or closes the disconnects manually, but at a distance from them. An auxiliary switch is so arranged that when the disconnecting switch blades are moved a short distance, and before they are open, it will complete the trip circuit on the oil switch, thereby opening the latter.

More interest is also being shown in the arrangement of buses and their bracing so as to give additional strength against short-circuit conditions. This is in line with the increased attention that has been paid to the rupturing capacity of circuit breakers, which has been mentioned previously in this article.

Most of the foregoing developments in substations have been brought about as the result of a desire for increased reliability of operation and safety to the operating personnel. One plant in the Chicago district that is not using truck-type switchboards, is using remote control for all circuit breakers, including all of the alternating-current and direct-current feeders, the carbon circuit breakers on the generators of motor-generator sets, as well as the magnetizing, starting, and running switches for the synchronous motors on these sets. The electrical superintendent in charge of this plant said that not only did this provide greater safety, but that it also greatly simplified the arrangement of the buses and feeders.

The search for the best all-around system of yard transportation continues slowly because of the excessive investment charges. Installations of third rail systems have been made, and have seemingly demonstrated that they can be operated without excessive danger to employees. A plant in the Youngstown district is trying out a storage battery locomotive for this work. Considerable interest was expressed by several operators in the Diesel-electric locomotive, the development of which is proceeding very satisfactorily. When production permits reasonable first cost, its very attractive operating characteristics will undoubtedly bring it into general use in steel plants.

### Trends in Use of Electric Heat in Steel Mills

The use of arc welding as a means of repairing worn and broken parts in steel mills has shown a great increase during the past year. The savings effected by arc welding a single worn or broken part have in a number of instances more than paid for the first cost of the welding equipment. Automatic arc welding is being used in some plants for building up worn shafts and for similar operations.

Conditions in the development of

arc furnaces for melting steel and iron have become fairly well established. There continues to be a steady, although slow, development of low-frequency induction furnaces for making high-grade steels and alloys. The field of the high-frequency induction furnace, however, has shown one of the most interesting developments of recent years. For many years it was thought that the high-frequency induction furnace could not successfully melt metals at frequencies lower than 5,000 cycles. However, it has been recently demonstrated that frequencies approximating 500 cycles will melt metals on a commercial basis with good efficiency.

With the expiration of patents covering certain alloys of great value for use in resistor units, a new impetus has been given to annealing and heat-treating furnaces.

Furnaces of large capacity with temperatures of 1,800-2,000 deg. F. are being installed in considerable numbers. Two electric furnaces for the continuous hardening, quenching and tempering of carbon-steel wire have been recently installed in wire mills. This process is said to result in a higher quality of wire than when the latter is treated in a gas-fired furnace.

Considerable interest has been displayed in an electrically-heated soaking pit which was installed by the Donner Steel Company a little over a year ago. These pits are heated with resistor-type units. The principal advantages claimed for this type of pit are more uniform heating due to accurate control of temperature, elimination of scale while in the pit, elimination of cutting of the ingot as in the case of sharp gas flames, and production of a better surface on the blooms. There is also a saving in space over gas-fired pits as well as a saving in foundations. When taking into consideration the saving in scale and with the usual cost of steel mill power, it is said that the cost of heating is less than by any other means, provided the ingots can be charged into the pits at such temperatures as are now common in steel mill practice. One steel mill engineer interviewed was particularly interested in the scale saving. This he said was an important factor in heating alloy steel such as is the product of his plant.

Reduction of inventories is being considered more carefully than ever before. It is hard to reduce inventories of spare parts after an installation has been made, but quite often a little foresight at the time of making an installation will save much money in spare parts. One engineer interviewed said that he was purchasing his motor equipment for a given installation at the very last. At this time he knows all of the details on all drives. It is then quite often possible to standardize on the capacities of motors required. Also, at this time it is usually possible to lay out the drives so as to cut down the number of speeds required. Similar capacities and types of motors are then purchased from only one manufacturer. The same is true of control equipment.

Another engineer stated that he was standardizing on the sizes of large motors as much as possible. He was also having this standardization carried to the bearings, coils and other parts of the motors. He said that by cutting the variety, sizes and types to a minimum he had been able to effect a saving of 50 per cent in the amount of spares mentioned in the original proposal. This, all of us will agree, was decidedly worth while.

# Pointers on Winding D. C. Armatures

*(Continued from page 435.)*

(2) When the center line of the coil falls on the mica, bar *M* is located by the use of the following formula: (lead pitch+active coils per cell)÷2. For example, assume that there are 47 slots, 93 bars, two coils per cell, one dead coil, coil pitch 1-and-11, or 10, lead pitch 1-and-47, or 46. The center line will fall on mica and slot, and slot *F* equals (10+2)÷2=6; bar *M* equals (46+2)÷2=24. Bar *N* equals 25, and bar *P* equals 47.

The above rules and formulas use the center line of the coil for laying off the winding data and can be used for any number of poles. The slots and bars should be marked as already explained.

The marking of the winding data on the core and commutator has the following advantages: When a sample coil is brought in from the coil department to check for throw, end room, etc., there is no time lost hunting up data, as the coil pitch is stamped on the core and the use of one cross on either side of the bottom slot also tells the coil man whether the coils should be right- or left-hand. In plants that do their own winding the marking of the slots eliminates the necessity of taking data the second time the armature comes in the shop for rewinding. All that is necessary is to check the lead pitch and the markings on the commutator in relation to the core markings to insure that the data have not been thrown off by commutator repairs. This check will only take about ten minutes to make and then the armature can be stripped by cheap help. Also, on four-pole machines the proper lead pitch is insured.

Next, we come to the cases where a half-idle bar is used. This type uses the diagram shown in Fig. 3 *B* and the rules governing the number of coils per cell, coil and lead pitch, line up of coil center line, etc., are the same as were given in connection with Fig. 3*D*, July issue, page 334, except that bar *M* equals [(commutator pitch)+(number of active coils per cell)—1]÷2, and bar *S* equals (commutator pitch+number of active coils per cell)÷2, and bars *x* and *y* are connected together by means of coils *1* and *2*. The first single coil to the left in the bottom of slot *1* should have its bottom lead cut off short, that is, not brought out to the commutator, and this short coil soldered to the adjacent coil lead in the same slot and to the right. Then the half-idle bar will be either bar *x* or *y*. These two bars should be considered as one bar in counting off lead pitch, etc. When stripping an armature that has one turn of strap copper coils and where it is desired to reinsulate the coils and use them again and the armature has a half-idle bar, the bottom coil leads should be numbered, calling the strap connecting to bar *1*, (Fig. 3 *B*,) No. 1, to *T*, No. 2, and to *R*, No. 3. Continue the lead marking until past bar *x*. The reason for this is that due to the bottom lead being cut off, and the half-idle bar, the remaining leads are stretched one bar until past the data coil. If the coils from another section of the armature were used at this point, they would not extend out flush with the outside surface of the commutator. In fact, a large number of winders mark all strap copper coils when reinsulating them, regardless of whether or not a dead coil or half-idle bar is used. This is a good policy to follow on old armatures, if the core is spread, but the starting slot should also be marked so that the winding will start in the same place on the core. Also, see that the coil leads are marked in the order in which they will be put back.

The top leads are generally the ones marked for left-hand coils. Start with the first single top coil to the left of the slot and call this No. 1, and make the numbers run clockwise. Then when rewinding, put in the coil with lead numbers 1, 2, 3, first; then coil leads 4, 5, 6, etc. For right-hand coils, call the first single top coil to the right No. 1 and mark the rest in a counter-clockwise direction.

# Graphic Meters for Detecting Grounds

*(Continued from page 417)*

Chart *B* of Fig. 3 shows the record taken at No. 3 substation at the same time. The ground appeared on this chart at 3:30 p.m. but the deflection continued on the chart during the period between 3:40 and 3:45 while the tie line connecting No. 2 and No. 3 substations was open. This clearly proved the trouble to be in the distribution from No. 3 substation.

These charts also showed that the ground was on intermittently as though it were a crane or some other start-stop drive that only operated for a very short period of time during its regular cycle of operation. Also, as can be seen from the charts, intermittent deflections are shown for a period of 20 min. which is followed by a corresponding idle period of 20 min.

This enabled the men to know that the ground was on one of the two billet chargers, for only one is in operation at a time and the operation of each one is limited to 20 min. periods.

Charts *D* and *E*, shown in Fig. 3, show the difference between a reversing and a permanent ground. Chart *D* is a reversing ground of the type found on the brush holder of a crane motor. Chart *E* is a permanent ground such as would occur from the grounding of a hot rail, feed line or collector ahead of the controller. Chart *C* of Fig. 5 shows a ground that reverses at intervals of about 10 min. and is of short duration.

Chart *F* of Fig. 5 shows a chart taken from No. 5 sub-station. Just before 10 a.m. a ground appeared that was quickly located on the brush holder of No. 6 squaring shear motor. Twenty-five minutes later another ground appeared which was not located and cleared until after 11 o'clock. When traced down the ground was found to be on the trolley bar of No. 31 crane.

An operating man must know the individual characteristics of his plant in order to derive full benefit from the graphic record of the grounds. However, a little study of the duration and interval of operation of different machines will enable him to definitely locate a faulty motor without the usual troublesome opening of circuit breakers and switches in the various power distribution stations and then haphazardly guessing at the machine in trouble until he finally locates the right one, which in some cases might be the last one tried.

In the plant in which these graphic ground detectors are installed there are 12,285 connected horsepower of motors. We find that with a graphic record of faulty d. c. equipment, the men follow up their work much closer. In addition to a material saving in maintenance costs, accurate records of all delays on d. c. equipment show that there has been a reduction of 26 per cent in production delays since the installation of these graphic ground meters.

# Trade Literature *You Should Know About*

***Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.***

**Wall Chart of Brush Styles**—A 12-in. by 16-in. wall chart illustrates the different styles and types of carbon brushes and gives directions for ordering.—Corliss Carbon Co., Bradford, Pa.

**Electrical Heating Unit**—Literature describes a new type of cartridge electrical resistance unit for industrial heating purposes.—Permway Electric Mfg. Co., 1921 Pine St., St. Louis, Mo.

**Speed Transformers**—Catalog 111 describes the construction and operation of the Ganschow speed transformers which are made in the planetary, compound and worm gear types as well as a special angle type speed transformer. Numerous illustrations, together with tables of dimensions and ratings, are included.—William Ganschow Co., 1001 W. Washington Blvd., Chicago, Ill.

**Electrical Supplies**—The 1925-1927 catalog of electrical supplies contains the complete line of equipment and supplies manufactured and distributed by this company. This publication contains 1,200 pages, is profusely illustrated with 4,500 engravings, and lists all new apparatus designed and manufactured in the past two years as well as all the previously established types. Four indices for the convenience of the user have been included in the present catalog. These include a complete subject index, a style number index, an index classified by industries, and a thumb index to the sections.—Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

**Speed Reducers**—Bulletin 38 devotes 48 pages to a description of the Falk herringbone speed reducers, their construction, operation, and advantages of the single-, double- and triple-reduction units. A number of installations are illustrated and dimensions and specifications given for the different reducer units. The Falk-Bibby flexible couplings are also described.—The Falk Corp., Milwaukee, Wis.

**Switchboard Instruction Book**—The installation, operation and maintenance of switchboards is fully covered in a new 120-page booklet, 87000-E, which is profusely illustrated with photographs, diagrams, tables, formulas and much other varied information of special value to those engaged in the construction, installation or operation of switchboards.—General Electric Co., Schenectady, N. Y.

**Composition Fiber Pulley**—A circular describes the Petralyke composition fiber pulley for use on severe belt drives such as on drop hammers, motors, generators and other similar service.—The Petralyke Corp., South Milwaukee, Wis.

**Flexible Couplings**—A circular describes the construction, operation and lubrication of the Fast flexible coupling which consists of spur gear hubs mounted on the ends of each of the two shafts. The gear teeth on these hubs mesh into a floating sleeve with internal gear teeth which surround the two hubs. The shafts and sleeves thus revolve as one unit but allow for lateral and angular play.—The Bartlett-Hayward Co., Scott & McHenry Sts., Baltimore, Md.

**Testing Apparatus and Instruments**—Circular 410 lists the different Biddle specialties for engineering and laboratory testing.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

**Insulating Varnishes and Compounds**—A recent 42-page booklet is more than a catalog of Ajax insulating varnishes and compounds in that it discusses, in addition to a description of each type of varnish and compound, the fundamental characteristics of insulating varnishes, gives an insulation guide and the characteristics of each of the baking and air-

drying varnishes in tabular form. In addition it gives general directions for the use of insulating varnishes, with suggested typical specifications for the varnish treatment of various types of electric motors, describes some common troubles found with insulating varnishes and discusses the method of testing these products.—The Sherwin-Williams Co., Cleveland, Ohio.

**Polyphase Motors**—Bulletin 38 describes and illustrates the construction of the Type SC, squirrel cage, polyphase induction motor which is constructed in ratings of ¼ to 75 hp. These are constant-speed, continuous-duty, open-rated motors.—Century Electric Co., St. Louis, Mo.

**Safety Limit Stop**—Bulletin 1040-B describes and illustrates the Youngstown safety limit stop for direct-current motors to prevent such accidents as the over-travel of electrical-driven machinery, particularly the over-hoisting of the hook blocks of electric cranes. This stop is made in three sizes; the No. 1 size is a new design of compact dimensions for use on small- and moderate- capacity cranes where space and mounting are restricted, while Nos. 2 and 3 are used on larger equipment.—The Electric Controller and Mfg. Co., Cleveland, Ohio.

**Friction Clutch**—Circulars describe the new Hoerl friction clutch and cut-off coupling which is of the cone and lever type with a Raybestos friction lining. Dimensions and directions for ordering are included.—The Wolf Co., Chambersburg, Pa.

**Bearings and Bushings**—Circulars describe the Ampco bearings, bearing metal and bushings, which are made of an alloy of copper, aluminum and iron. Instructions on how to order, and lists of the dimensions of bushing stock carried, are also given. Other circulars describe the use of this material in acid-resisting castings, chains and hooks for pickling vats, acid valves and other purposes.—American Metal Products Co., 34th Ave. & Burnham St., Milwaukee, Wis.

**Standardized Substation**—Bulletin 12 describes a new line of standardized steel tower outdoor substations intended for installation by utilities serving, or customers buying, power from high-tension distribution lines.—Delta-Star Electric Co., 2433-2461 Fulton St., Chicago, Ill.

**Constant-Speed Polyphase Induction Motors**—Bulletin 143 describes the Type L, constant-speed, polyphase induction motors. These are made in ratings from ¼ hp. to 75 hp., two and three phase, 110, 220, 440 and 550 volts. Practically all ratings may be obtained in from two to four speeds.—The Robbins & Myers Co., Springfield, Ohio.

**Special Tooth Gears**—Circular 265-I and other literature describe the construction and use of the Maag-generated, full-involute tooth gears. These gears are made in spur gear, herringbone or spiral forms and up to 40 ft. in diameter. The Maag tooth has an extra thick base, but is not a stub tooth.—Niles-Bement-Pond Co., 111 Broadway, New York City.

**Pneumatic Drills**—Recent literature describes a new line of four-cylinder, reversible and non-reversible pneumatic drills, which are equipped with speed governors that automatically prevent racing the drills beyond the safe working speed.—Ingersoll-Rand Co., 11 Broadway, New York City.

**Portable Electric Drill**—Special bulletin G-30 describes a new improved special ½-in. drill, which is equipped with a universal, ball-bearing motor and is fitted with cord and plug, combination spade handle and breast-plate and three-jaw geared chuck. Other types of electric drills, bench drill stands, bench grinders, post grinders and other tools are also described.—The Standard Electric Tool Co., Cincinnati, Ohio.

**Seamless Metal Hose**—Bulletin 201-29-A describes a flexible seamless metal hose or flexible pipe which is made by corrugating in spirals either seamless bronze or seamless steel tubing. Fittings are welded on and it is claimed that hose of double structure has been subjected to tests up to 10,000 lb. hydrostatic pressure, and to temperatures as high as 1,000 deg. F.—Chas. Cory & Son, Inc., 183-7 Varick St., New York City.

**Special Machinery**—An interestingly-illustrated booklet shows some of the facilities of this organization for producing heavy machinery of special design.—Dodge Manufacturing Corp., Mishawaka, Ind.

## Publishers Form Corporation to Cover Foreign Markets

ESTABLISHMENT of the Business Publishers' International Corporation to meet more adequately the demand for specialized business publications in the fields of overseas trade and industry has been announced by the McGraw-Hill Company and the United Publishers' Corporation. They jointly will control the new organization.

Three publications already in existence form the nucleus of the new company, which will maintain editorial and business representatives in the important commercial centers abroad. The papers are *Ingenieria Internacional* (*International Engineering*), a McGraw-Hill industrial and engineering monthly circulating in Spain and Latin America; *El Automovil Americano* and *The American Automobile* (*Overseas Edition*) in Australia, New Zealand, South Africa, India, Great Britain, Norway, Denmark, Holland, Belgium, in the Orient and in other territories.

The new corporation is headed by Mason Britton, President, who is a Vice-President of the McGraw-Hill Company. John Abbink, until formation of the new publishing firm, Business Manager of *Ingenieria Internacional*, is Vice-President and General Manager. J. L. Gilbert, who was Business Manager of the two automotive publications, is Vice-President and Secretary. C. A. Musselman, President of the Chilton Class Journal Company, the automotive publications division of the United Publishers' Corporation, is Treasurer.

The Board of Directors includes, in addition to the officers, Charles G. Phillips, President of the United Publishers' Corporation; Malcolm Muir, a Vice-President of the McGraw-Hill Company; Philip S. Smith, Editor of *Ingenieria Internacional;* and George E. Quisenberry, Editor of *El Automovil Americano* and *The American Automobile* (*Overseas Edition*).

# Planning a Line-shaft Installation

(*Continued from page 422*)

the best industrial operating practice, generally, and while it may give the lowest first cost of the installation it would probably be better to design the drive to operate at a higher belt speed.

Still another important point to take into account is the proper location of the motor. Obviously it would be an undesirable type of drive to have the motor located at one end of the shaft and the heaviest machine at the other. In such a case, if the machine produced shock loads, the twisting effort on the shaft would be extremely undesirable. It is usually best to place the motor so that about an equal amount of power is taken off on either side of the pulley connected to the motor. A method of doing this graphically, which was also worked out by R. C. Moore, is shown in the illustration at the top of page 422.

One of the advantages of group drive which was not mentioned is that the total horsepower required to operate the group varies from 1/5 to 1/2 of that which is specified for the operation of each individual machine. One illustration of this fact as applied to a special group of small machine tools is shown in the table on page 421.

Still another advantage of using a number of small group drives instead of one large group, is that pulleys of standard bore in the small diameters may be used. Also, it is well to standardize on a few diameters of lineshaft so that a pulley may be transferred from one lineshaft to another. In many plants the storerooms are filled with pulleys with odd-size bores, which will fit only on special shafts. This problem is not so serious, however, where split pulleys and bushings are used.

There are many factors, such as the building construction and placing of the motor or shaft in a definite location, which necessitate a compromise between the best and the necessary. On large installations of power transmission equipment it is advisable to consult with the manufacturer's engineering staff.

EDITOR'S NOTE: Special acknowledgment is made to K. W. Knorr, Engineer and District Sales Manager, Dodge Mfg. Co., Mishawaka, Ind., and to R. C. Moore, Chief Engineer, Chas. A. Schieren Co., New York City, for assistance in the preparation of this article.